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DEREK JOHN GOBBETT

CARBONIFEROUS AND PERMIAN BRACHIOPODS OF SVALBARD

WITH 27 FIGURES IN THE TEXT AND 25 PLATES

NORSK POLARINSTITUTT
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PREFACE

This study was originally submitted for the degree of Doctor of Philosophy at Cambridge University. This paper is a slightly modified version of that dissertation with a necessary reduction in the number of plates. It is largely descriptive and purports to be an index to the Svalbard brachiopod faunas rather than an ecological or palaeo-geographical study. The stratigraphical implications herein are important in any consideration of arctic Upper Palaeozoic stratigraphy but they must be tested by further work on the other components of the fauna, particularly the polyzoa and the fusuline foraminifera. This work is being continued at Cambridge by J. CUTBILL and it is to be hoped that, before long, a more detailed picture of the Carboniferous and Permian of Svalbard will emerge.

In the summers of 1958 and 1959, I visited Spitsbergen and was able to collect brachiopods from Ny Friesland, Bünsow Land and Dickson Land. However, the results of my own collecting were but a small fraction of the specimens available to me for study. Many individuals have been involved in collecting the brachiopods now in the Sedgwick Museum. I would like to acknowledge the field work of the following: Mr. W. B. HARLAND (1938 Cambridge Spitsbergen Expedition); Mr. E. DUFFEY, Mr. J. LOWY, and Mr. D. E. SERGEANT (1948 Bear Island Expedition); Dr. C. L. FORBES, Mr. W. B. HARLAND, Mr. J. S. PAGE, Dr. R. W. MCWHAE, Dr. O. P. SINGLETON, and Mr. R. J. TAUNTON (1949 Cambridge Spitsbergen Expedition); Dr. M. P. H. BOTT (1951 Oxford and Cambridge Expedition); Mr. M. B. BAYLY and Mr. P. H. BAILEY (1952 British Spitsbergen Expedition); Mr. R. WEBBE (1952 Sherborne School Spitsbergen Expedition); Mr. J. H. LATTER and Mr. R. WEBBE (1954 British (Sherborne-Cambridge) Spitsbergen Expedition); Mr. R. F. ATHERTON, Dr. P. F. FRIEND, and Mr. P. R. SIMPSON (1958 Cambridge Spitsbergen Expedition); Miss M. DETTMAN, Mr. J. L. FORTESQUE, Dr. P. F. FRIEND, Mr. D. G. GEE, Mr. R. V. LONGE, Dr. G. PLAYFORD, Mr. R. G. W. PRESCOTT, and Mr. M. S. THORNTON (1959 Cambridge Svalbard Expedition); Mr. W. B. HARLAND and Mr. N. F. HUGHES (1960 International Geological Congress Excursion).

I am grateful to Prof. O. M. B. BULMAN for research facilities in the Sedgwick Museum.

Field notes, maps and collections have been made available to me by Mr. W. B. HARLAND to whom I am sincerely grateful and to whom I am indebted for guiding the course of my work including the preparation of this paper. Regarding the latter I wish to thank Dr. C. L. FORBES, Assistant Curator of the Sedgwick Muse-

um, and Mrs. K. N. HEROD for their detailed checking of the manuscript in the course of numbering and cataloguing the specimens in the Sedgwick Museum.

I am also indebted to the following for their assistance: Dr. K. BIRKENMAJER and Mr. S. CZARNIECKI (Polish Academy of Sciences) for discussion and the loan of specimens; Dr. K. S. W. CAMPBELL (University of New England, Armidale) for advice and encouragement in the initial stages of the work; Mr. A. CHALLINOR and Dr. M. R. HOUSE (University of Durham) for loan of specimens from Kongsfjorden, collected by the 1960 Durham Spitsbergen Expedition; Dr. D. L. DINELEY (University of Ottawa) and Mr. P. GARRETT (University of Birmingham) for discussion, access to MS. and the loan of specimens from Oscar II Land collected by the 1954 Birmingham Spitsbergen Expedition; Dr. E. FLÜGEL (Naturhistorisches Museum, Vienna) for the loan of TOULA's specimens, including his described material; Prof. A. HEINTZ (Paleontologisk Museum, Oslo) for allowing me access to the Norwegian collections and for the loan of specimens; Mr. J. W. S. JACKSON (National Museum of Ireland) for the loan of HAUGHTON's described material from arctic Canada; Dr. H. M. MUIR-WOOD (British Museum, Natural History) for advice, critical discussion and the loan of specimens; Dr. H. MUTVEI (Naturhistoriska Riksmuséet, Stockholm) for allowing me access to the Swedish collections and for the loan of specimens; Prof. C. POULSEN (Mineralogisk Museum, Copenhagen) for allowing me access to the brachiopod collections from central east and northeast Greenland; Prof. P. PRUVOST (Laboratoire de Géologie à la Sorbonne, Paris) for the loan of specimens belonging to the DEREIM's collection from Bolivia; Dr. M. J. S. RUDWICK (Sedgwick Museum) for my first detailed introduction to brachiopods and for advice on techniques; Dr. J. SORNAY (Institut de Paléontologie, Paris) for the gift of plaster casts of Bolivian specimens described by D'ORBIGNY; Prof. D. L. STEPANOV (University of Leningrad) for gifts of reprints and photocopies and for discussion; Dr. T. S. WINSNES (Norsk Polarinstitutt, Oslo) for access to MS. and specimens and for discussion.

Mr. A. BARLOW gave advice and help with the photography at Cambridge and TENGKU ISMAIL BIN TENGKU MOHAMED helped to print photographs in Malaya. For the final preparation of this paper and for seeing it through the press I am indebted to Mrs. N. HEINTZ, Mrs. K. HEROD, and Mr. W. B. HARLAND. The bulk of the work was carried out during the tenure of a D.S.I.R. maintenance grant.

Kuala Lumpur.
Pantai Valley,
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January, 1962.

Contents

ABSTRACT

Following a review of previous research, an account is given of the Carboniferous and Permian stratigraphy of Svalbard, with special reference to the occurrence and content of brachiopod faunas. This is supplementary to the work of C. WIMAN, H. FREBOLD and D. L. STEPANOV. Correlation of the Carboniferous and Permian within Svalbard is based partly on three brachiopod faunas. The oldest fauna occurs in the dominantly red-bed and evaporite sequences which locally succeed the continental Lower Carboniferous. The succeeding thick limestones contain Sakmarian brachiopods, and a third brachiopod fauna occurs in the uppermost beds (Brachiopod Chert) of the Svalbard Permian.

The brachiopods collected by British, Norwegian, and Swedish expeditions over the last century are systematically revised; 143 species are described and their known occurrence in Svalbard and in other arctic areas is given. Nineteen species are new, *viz. Lingula freboldi, Orbiculoidea winsnesi, Liosotella proboscidea, Productus anderssoni, Reticulatia holtedahli, Horridonia geniculata, Cancrinella singletoni, C. spitsbergiana, C. tenuissima, C. crassa, Megousia harlandi, Chonetina superba, Paeckelmannia forbesi, Spirifer striatoplicatus, Brachythyrina arctica, Licharewia spitsbergiana, Choristites aliforme, Pseudosyrinx wimani,* and *Pseudosyringothyris borealis.* Another eight species of doubtful occurrence or of uncertain systematic position are mentioned.

The Brachiopod Chert fauna is briefly compared with other Permian brachiopod faunas of the U.S.S.R., arctic North America and Greenland. It has both Lower and Upper Permian affinities and constitutes a basis for the Svalbardian stage. This is possibly an age-equivalent either to the stratigraphic break widespread in the U.S.S.R. between the Lower and Upper Permian or to the lower part of the Russian Kazanian.

I. INTRODUCTION

Svalbard (see map, Fig. 1) is a group name for the islands in the Arctic Ocean situated between latitudes 74° N and 81° N and longitudes 10° E and 35° E. It has been under the sovereignty of Norway since 1920. The largest of the islands are Vestspitsbergen and Nordaustlandet which, together with Edgeøya, Barentsøya and Prins Karls Forland, are called Spitsbergen.

Previous research

In spite of its geographical position and consequent inhospitable climate, Svalbard was visited frequently by hunting expeditions in the 17th and 18th centuries. Thus a considerable amount was known about its geography prior to the start of geological investigations by scientific expeditions early in the 19th century. Some of the first fossils to be collected were silicified Upper Palaeozoic brachiopods picked up from scree or glacier moraine. The study of these, and of the stratigraphical relations of the beds from which they were later collected *in situ,* may be conveniently divided into three periods.

1. The 19th century before the works of TSCHERNYSCHEW (1898) and ANDERSSON (1900).
2. The period 1898–1940, during which studies of the Carboniferous and Permian of Svalbard were dominated by TSCHERNYSCHEW's (1902) work on the "Upper Carboniferous" brachiopods of the Ural and Timan. Also the presence of Middle Carboniferous strata was established in Bjørnøya and, later, in Spitsbergen.
3. After 1940, when it was possible to review the Carboniferous and Permian stratigraphy in the light of more advanced studies on the Russian, American and arctic faunas, notably fusulines.

1. The first recorded observations on the Carboniferous and Permian rocks were made in 1827. While PARRY was attempting to reach the North Pole by crossing the polar ice to the north of Nordaustlandet, his lieutenant, FOSTER, mapped Hinlopenstretet[1] and collected some silicified fossils, including *"Terebratulites",* from the limestones of Kapp Fanshawe (PARRY 1828, p. 227). The same summer KEILHAU visited Bjørnøya and collected brachiopods from Misery-

[1] For localities mentioned in the text see Figs. 2–8.

fjellet. These were studied by VON BUCH (1847) who listed (p. 9), without citing authors, *Productus giganteus, Productus striatus* and *Productus punctatus* from bed "J or 7" of KEILHAU's profile (i. e. the Spirifer Limestone, see below). He also recorded *Productus plicatilis* and *Spirifer keilhavii* from fallen blocks on the slopes of Miseryfjellet. KEILHAU visited the southern part of Spitsbergen and reported the occurrence of *P. giganteus* at Sørkapp and Bellsund.

Apart from *Spirifer keilhavii,* a new species, these brachiopods were incorrectly identified with European Lower Carboniferous forms. This was in spite of the observation that the coal-bearing rocks of Bjørnøya were overlain by *Productus*-bearing limestones, thus differing from the Carboniferous sequence of north-west Europe.

In 1838 fossils were collected from a dark to light grey magnesian limestone at Reinodden, Bellsund, by the French expedition in the "Recherche". These were figured by ROBERT (1845) who identified Carboniferous species of brachiopods. However, DE KONINCK (1846) related some of the brachiopods with Permian species and, as his views were questioned by ROBERT, he subsequently (1850) described and figured the shells, re-identifying some of ROBERT's specimens as follows:

Robert 1845, pl. 19, figs. D–M	DE KONINCK 1850, figs. 1–6
D. *Productus costatus* SOW.	
E. *Spirifer lineatus?* PHIL.	
F, G. *Productus martini* SOW.	3. *Productus leplayi?* VERN.
H, I. *Productus punctatus* SOW.	2. *Productus cancrini* VERN.
J. not identified	1. *Productus horridus* SOW.
K. *Spirifer cordieri* sp. nov.	5. *Spirifer alatus* SCHLOTH. var.
L. *Spirifer octoplicatus* SOW.	6. *Spirifer cristatus* SCHLOTH. var.
M. *Productus*	

[The present determinations of ROBERT's figures are as follows: D. ?*Kochiproductus porrectus* (KUTORGA), E. ?*Cleiothyridina kotlukovi* STEPANOV, F, G. *Muirwoodia duplex* (WIMAN), H, I. *Cancrinella spitsbergiana* sp. nov., J. *Liosotella pseudohorrida* (WIMAN), K. *Paeckelmannella cordieri* (ROBERT), L. ?*Spiriferina cristata* (SCHLOTH.), M. ?*Cancrinella sp.*]

Evidence for the Lower Carboniferous age of these fossils was adduced by ROBERT (1842, 1856) who interpreted the section from which they were obtained as consisting of marine limestones overlain by thick coal measures with *Calamites, Sigillaria,* and *Lepidodendron*. [In 1882, NATHORST and DE GEER observed that ROBERT's section, on the east side of Recherchefjorden, was overturned, the "coal measures" being older than the "marine limestones".]

SALTER (1860) was the next author to describe "Carboniferous" brachiopods from Spitsbergen. These were collected by LAMONT in 1859, mainly from Akseløya in Bellsund, and include *Bathymyonia*? sp. and *Muirwoodia duplex* (WIMAN) (see systematic descriptions, section III). SALTER determined these respectively as *Productus* sp. nov. and *Productus mammatus?* KEYSERLING. He recorded also *Productus costatus* SOW., *Productus* sp., *Productus humboldti* D'ORB., *Camerophoria* sp., and *Spirifer keilhavii* VON BUCH, a large, smooth *Athyris* or *Spirifer* sp.

"nearly 3 inches across, without any definite hinge line, and with very strong, ventral muscle impressions" (SALTER 1860, p. 439). The latter may have been a specimen of *Cleiothyridina kotlukovi* STEPANOV (see systematic descriptions). *Spirifer cristatus* SCHLOTH., was listed, but SALTER regarded this as conspecific with *S. octoplicatus* SOW. of the Mountain Limestone. One Zechstein species, *Spirifer alatus* SCHLOTH. was recorded from a loose block of white limestone at Negerpynten at the southern tip of Edgeøya.

In 1837 S. LOVÉN visited Isfjorden and brought back Upper Palaeozoic fossils to Stockholm. His collection was augmented by those of a series of Swedish expeditions in 1858, 1861, 1864, and 1868. According to NORDENSKIÖLD (1866) the fossils were to have been described by ANGELIN but I can trace no published account of them.

From the observations of these Swedish expeditions, and those of NATHORST and WILANDER in 1870 in Billefjorden, NORDENSKIÖLD (1863, 1866, 1871, 1875) synthesized a stratigraphic sequence as follows:

TRIAS		? Including sandstone with plant remains in Bellsund.
PERMIAN		Controversial: ? loose block with *S. alatus* (SALTER 1860).
UPPER COAL FORMATION		Sandstones and plants on the east side of Recherchefjorden. [Section here inverted.]
MOUNTAIN LIMESTONE PROPER	U. 2000'	Productus Limestone and Chert, intruded by dolerite. Spirifer Limestone
	L. 1500'	Kapp Fanshawe or Cyathophyllum Limestone. Sandstone, with coal and plant remains, at Kapp Fanshawe. Ryssö Dolomite. [Now known to belong to the Hecla Hoek Series.]
LOWER MOUNTAIN LIMESTONE	1000' 2000'	"Ursa-stufe" of Bjørnøya, and sandstones, shales and thin coals in Spitsbergen.

LINDSTRÖM (in NORDENSKIÖLD 1876, p. 69–71) determined 63 species of fossils from the Mountain Limestone of which 34 were brachiopods. He named only 16 species and described these as a mixture of Carboniferous species and typical Permian species, such as *Camerophoria humbletonensis* HOWSE, *Productus cancrini* VERN., *Productus leplayi* VERN., *Productus horridus* SOW., and *Strophalosia lamellosa* GEINITZ. He concluded (p. 71):

The final result of these preliminary examinations is that the strata from which the fossils are derived truly belong to a division of the Mountain Limestone of the Carboniferous formation, but possess a peculiar character from the intermixture of species occurring in other countries only in the Permian formation. In consequence of the occurrence of these Permian types, the suppo-

sition lies ready to hand that the Mountain Limestone of Spitsbergen is a later link, if not corresponding, at least analogous to the Upper Mountain Limestone of Scotland, which is separated from the Lower Mountain Limestone by a series of Coal-beds.

The first detailed descriptions of Spitsbergen brachiopods were published by TOULA (1874, 1875 a, 1875 c). He described specimens collected by three Austrian expeditions (those of PAYER and WEYPRECHT 1871–72, WILCZEK 1872 and R. VON DRASCHE-WARTINBERG 1873), from the Productus Limestone and Chert of Sørkappøya, Hornsund, Bellsund, and Nordfjorden.

TOULA described 47 species and varieties, of which 14 species and five varieties were new. The rest were identified mainly with Lower Carboniferous forms but some with Zechstein species. TOULA did not discuss the age of the brachiopod-bearing strata or attempt to correlate them with other successions; he regarded them broadly as Permo-Carboniferous. VON MORECHALL (1875), commenting on TOULA's list of species from Hornsund, pointed out that they showed both Carboniferous and Permian affinities. He interpreted the strata containing both *"Productus longispinus"* and *"Strophalosia cancrini"* as transitional between Carboniferous and Permian.

LUNDGREN (1887) described "Permian" fossils from material collected on Mariaholmen, Bellsund, by NATHORST and DE GEER in 1882. The brachiopods included *"Discina" spitzbergensis* LUNDGREN, *Retzia nathorsti* LUNDGREN and *Terebratula*? sp. These were found in a thin impure limestone, the "Retziakalk", about 300 m above the top of the Productus Limestone and Chert. TSCHERNYSCHEW (1902) identified *R. nathorsti* with *Hustedia remota* EICHWALD, but FREBOLD (1939) disputed this and showed that the lamellibranchs in the shales below the "Retziakalk" had affinities with the Eo-Triassic fauna of east Greenland.

2. TSCHERNYSCHEW (1898) first attempted a precise correlation of the Spitsbergen "Permo-Carboniferous" with the Russian succession, as follows:

Spitsbergen	– Ural
Productus Chert	– Artinskian
Spirifer Limestone	– Schwagerina horizon
Cyathophyllum Limestone	– Cora horizon

These correlations were based on brachipods which TSCHERNYSCHEW considered common to Svalbard and Russia. In the Swedish (Stockholm) collections, he identified the following brachiopods (TSCHERNYSCHEW 1898, 1902).

Cyathophyllum Limestone: *Productus cora* D'ORB., *P. konincki* VERN., *P. lineatus* WAAGEN, *Chonetes variolata* D'ORB., *Athyris royssi* L'ÉVEILLÉ.

Spirifer Limestone: *Dielasma plica* (KUT.), *D. moelleri* TSCHERN., *Spiriferina saranae* (VERN.), *Spirifer keilhavii* BUCH, *S. cameratus* MORTON, *Camerophoria plicata* KUT., *Rhynchopora nikitini* TSCHERN., *Derbyia regularis* WAAGEN, *Chonetes granulifera* OWEN, *C. variolata* D'ORB., *Productus aagardi* TOULA, *P. timanicus* STUCK., *P. pseudoaculeatus* KROT., *P. porrectus* KUT., *P. boliviensis* D'ORB., *P. uralicus* TSCHERN., *P. multistriatus* MEEK, *P. orientalis* TSCHERN.

Brachiopod Limestone and Chert: *Spirifer fasciger* KEYS., *S. alatus* SCHLOTH., *Derbyia senilis* PHILL., *Productus post-carbonarius* TSCHERN., *P. cancriniformis* TSCHERN.

The correlation of the Productus Chert with the Artinskian was influenced by the occurrence, in both deposits, of the sponge *Pemmatites,* first described from Spitsbergen by DUNIKOWSKI (1884). This correlation was followed by FRECH (1901, p. 496–8) who refigured some of TOULA's original specimens and revised some of the species.

Middle Carboniferous deposits were first proved on Bjørnøya where the stratigraphy was studied by NATHORST's 1898 expedition. The following year ANDERSSON spent two months on the island and subsequently (ANDERSSON 1900) published a general stratigraphical account with fossil lists.

Above the continental sandstones of the "Ursa-stufe" was the Ambigua Limestone, a series of sandstones and limestones with *"Athyris" ambigua.* Besides the latter, ANDERSSON recorded *Eumetria serpentina?* (KONINCK), *Spirifer supramosquensis* NIKITIN, *Productus corrugatus* M'COY, and *Productus undiferus* KONINCK. Of these the first determination may be correct, the second is a *Choristites* sp., *P. corrugatus* is represented by a few Linoproductid fragments in the Stockholm collections, and *"Productus undiferus"* is a new species of *Productus s.s.* described below.

The Ambigua Limestone was followed by a series of unfossiliferous yellow sandstones and finally a fusuline-rich limestone (Fusuline Limestone), containing one brachiopod species, identified as *Camerophoria isorhyncha* M'COY. This was later determined by TSCHERNYSCHEW as *Camerophoria plicata* KUT. (ANDERSSON 1900, p. 279).

These marine deposits were attributed to the Middle Carboniferous. ANDERSSON divided the unconformable Upper Carboniferous into a lower, Cora Limestone, and an upper, Spirifer Limestone, separated by an unconformity. The Cora Limestone contained the following brachiopods, (the present determination is put in square brackets): *Productus boliviensis* D'ORB. [?], *P. cora* D'ORB. [?*Linoproductus dorotheevi* (FREDS.)], *P. humboldti* D'ORB. [*Waagenoconcha irginae* (STUCK.)], *P. koninckianus* VERN. [?*Cancrinella singletoni* sp. nov.], *Spiriferina saranae* VERN. [*Spiriferella* cf. saranae (VERN.)], *Reticularia lineata* MART. [*Neophricadothyris asiatica* (CHAO)], *Camerophoria purdoni* DAVIDSON [?], *Rhynchopora nikitini* TSCHERN. [?].

The Spirifer Limestone contained an ubiquitous brachiopod fauna. This was listed as: *Derbyia* sp. [*Streptorhynchus kempei* WIMAN], *Productus uralicus* TSCHERN. [*Costinifera arctica* (WHIT.)], *P. timanicus* STUCK. [*Horridonia timanica* (STUCK.)], *P. purdoni?* DAVIDSON [*Waagenoconcha wimani* (FREDS.)], *Spirifer keilhavii* BUCH. [*Spiriferella keilhavii* (BUCH.)], *Reticularia lineata* MART. [?*Cleiothyridina royssiana* (KEYS.)], *Rhynchopora nikitini* TSCHERN. [*idem*].

TSCHERNYCHEW visited the south-east part of Spitsbergen in 1899 as leader of the Russian section of the Russian-Swedish Arc of Meridian Expedition. On his return journey to St. Petersburg he visited Uppsala and examined ANDERSSON's Bjørnøya collections. TSCHERNYSCHEW (1902) correlated the Svalbard and Russian successions as he had in 1898 except that he regarded the lower part of the Cyathophyllum Limestone as equivalent to the Omphalotrochus horizon of the Timan. He accepted the existence of the Middle Carboniferous deposits of Bjørnøya but doubted their presence in Spitsbergen. The evidence for the latter had been based

on the occurrence of fusulines in the middle part of the Cyathophyllum Limestone, which were identified by GOËS (1884) as *Fusulina cylindrica* FISCHER. TSCHERNYSCHEW doubted the validity of this determination and was also sceptical about the occurrence of *Spirifer mosquensis* FISCHER in Spitsbergen. ANDERSSON had identified a specimen of the latter from Kapp Fanshawe in the Swedish collections; TSCHERNYSCHEW compared this with *Spirifer fritschi* SCHELLWIEN.

SCHELLWIEN (1908), in his work on the arctic fusulines, described four species from the Fusulina Limestone of Svalbard. In the stratigraphical part of this work STAFF correlated the beds containing these with the lower part of the Russian Schwagerina horizon and the rest of the Cyathophyllum Limestone with the Russian Cora horizon.

NATHORST (1910) published a general account of the geology of Svalbard. He described gypsum beds lying between Culm sandstones and Cyathophyllum Limestone in Billefjorden and suggested they might be equivalent to the Middle Carboniferous of Bjørnøya. The following year HOLTEDAHL (1911) described Middle Carboniferous (Moscovian) brachiopods from a thin, richly fossiliferous limestone, about 130 m below the Fusulina Limestone (i. e. mid-Cyathophyllum Limestone) on the north side of Scheteligfjellet, Brøggerhalvøya. The fauna included crinoids and corals but brachiopods were the most numerous and are listed below in Section II.

HOLTEDAHL (1913) described fossils from the Cyathophyllum Limestone of outer Isfjorden and Brøggerhalvøya. Among these were four brachiopods; *Spiriferina* sp., *Martinia* cf. *parvula* TSCHERN., *Hustedia remota* EICH., and *Productus longispinus* SOW., but I have been unable to find these specimens in Oslo where they are reputedly housed.

WIMAN (1914) produced the first monographic work on Svalbard Carboniferous and Permian brachiopods; this was based on the Swedish collections. He recorded 90 species of which nine were new, but figured only 33. The majority of the figured specimens were from the Spirifer Limestone. Of these Spirifer Limestone species, a quarter were indigenous to Svalbard whilst many of the remainder were closely allied to Russian forms. Most of the species from below the Spirifer Limestone were quoted from ANDERSSON (1900), TSCHERNYSCHEW (1902), and HOLTEDAHL (1911). In his correlation of the Svalbard and Russian successions, WIMAN argued that if STAFF (in SCHELLWIEN 1908, p. 147–160) was correct in regarding the Fusulina Limestone of Spitsbergen as an age-equivalent of the Schwagerina horizon, then it could not be the same age as the Fusulina Limestone of Bjørnøya, which underlies the Cora Limestone. GRABAU (1931) overcame this difficulty by proposing the following correlation. (See next page.)

This was subsequently modified by FREBOLD (1936, 1937). In 1937, FREBOLD described the brachiopods collected by several Norwegian expeditions, and largely by HOEL, from 23 precisely located horizons in the Festningen section at the mouth of Isfjorden. Nearly all the species had been described previously from the Spirifer Limestone and Brachiopod Chert. However, from the lowest horizon (23) Frebold described a subspecies of *Linoproductus cora* and identified it with *L. cora planus* MILORADOVICH, a form originally described from Novaya Zemlya. On the basis of this one subspecies he correlated horizon 23 with the

	Bjørnøya	Spitsbergen
ARTINSKIAN	Spirifer Limestone	Brachiopod Chert
	hiatus	
SCHWAGERINA HORIZON	Cora Limestone	Spirifer Limestone
	hiatus	Upper part of Cyathophyllum Limestone
	Fusulina Limestone	Fusulina Limestone

Cora Limestone of Russia and Bjørnøya. Horizon 12 was correlated with the Spirifer Limestone of inner Isfjorden as it contained species of *"Spirifer"* and *"Productus"* not present in the collections from lower horizons. Thus the chert beds between horizons 23 and 12 were said to be represented in Billefjorden by evaporite deposits and in Bjørnøya by a hiatus in the sequence. To support this FREBOLD pointed out that the thickness of the chert in Billefjorden (after WIMAN 1914) is less than at Festningen or Bellsund. However, this is now known to be incorrect (see GEE, HARLAND, and MCWHAE, 1953, p. 330 and below). FREBOLD considered the age of the Spirifer Limestone to be uppermost Upper Carboniferous, (i. e. Lower Permian if the Carboniferous–Permian boundary is placed between the *Triticites* and *Pseudoschwagerina* zones after DUNBAR 1940).

3. STEPANOV (1936, 1937 a) described the brachiopods collected by KOTLUKOV and LUTKEWICH, mainly from the Spirifer Limestone and Brachiopod Chert of Isfjorden. He revised some of the earlier determinations and described five new species. This author concluded that the fauna of the two formations was essentially similar. It compared with the Upper Kungurian or Lower Kazanian fauna of Russia and had affinities with the Word fauna of the U. S. A. In spite of STEPANOV's views, ORVIN (1940) and GEE *et al.* (1953) followed FREBOLD's (1937) correlation and age determinations.

WANG (in GEE *et al.* 1953, p. 347) listed brachiopods collected by the 1938 Cambridge Spitsbergen Expedition from the Cyathophyllum Limestone and Spirifer Limestone of Bünsow Land. These are revised below in section III. The 1949 Cambridge Spitsbergen Expedition (see GEE *et al.* 1953) studied in detail the Carboniferous and Permian stratigraphy of Bünsow Land and made large and valuable fossil collections (listed in FORBES, HARLAND & HUGHES 1958); the brachiopods collected form the basis of the present study. Much of the Bünsow Land succession appears to be continuous and, although it contains unfossiliferous evaporite facies, provides a good reference area.

A thin, fusuline-rich member (Mid Wordiekammen Limestone) occurs in Bünsow Land in the middle of the Cyathophyllum Limestone sequence. The fusuline foraminifera it contains (FORBES *et al.* 1958, FORBES 1960) are characteristic of both the *Triticites* and *Pseudoschwagerina* zones of DUNBAR (1940); thus it

may be considered transitional between the Carboniferous and the Permian. The upper part of the Cyathophyllum Limestone is thus of Sakmarian age and the Spirifer Limestone is Artinskian or younger.

STEPANOV (1957) argued that the Russian stages Kungurian and Ufimian both have a restricted fauna and are of local significance only. They should be regarded as facies. He suggested that a more reliable stage between the Artinskian and the Kazanian was to be found in the marine succession of the Arctic and proposed a new stage name, Svalbardian, comprising the Spirifer Limestone and the Brachiopod Chert of Svalbard and the Permian of east Greenland. However, it is probably more correct to regard the Svalbardian as another facies. It is doubtful whether it can ever be recognized as a stage in the sense of a Triassic or a Jurassic stage.

The present study

Most problems have resulted from attempts to correlate sequences in different parts of Svalbard with TSCHERNYSCHEW's "Upper Carboniferous" succession in the Ural and Timan, which was itself in part erroneous (see DUNBAR 1940). The three horizons established by TSCHERNYSCHEW (1902) were, in ascending order, those of Omphalotrochus, Cora, and Schwagerina.

The Omphalotrochus horizon was founded by TSCHERNYSCHEW for the north Ural and Timan. He divided it into a lower, coral horizon and an upper horizon of *Spirifer marcoui*. Later studies have shown that the Omphalotrochus horizon includes beds of different ages, mostly Sakmarian, and in the Timan includes some Upper Carboniferous strata (LICHAREW 1958). It is not used now as a stratigraphic term.

The Cora horizon was established in the Ufa plateau by TSCHERNYSCHEW in 1886. He later extended it to the Timan to include limestones rich in *"Productus" cora* and other marine fossils and used it as a term for all the beds lying between the Omphalotrochus horizon and the Schwagerina horizon. In the Ufa plateau it corresponds to the Burtsevka and Irgina Series of Lower to Middle Artinskian age (LICHAREW 1958). The term "Cora horizon" is no longer used in Russian stratigraphy.

The Schwagerina horizon was established by NIKITIN (1886) in the Volga region. Here it lies between the Pseudofusulina zone (upper Carboniferous, Orenbergian) and the Tastuba horizon (Upper Sakmarian) and is thus Lower Sakmarian in age. TSCHERNYSCHEW's "Schwagerina horizon" in the north Ural and Timan was, at least in part, younger (Upper Sakmarian or Lower Artinskian (STEPANOV 1958)), and it was with this higher horizon that he correlated, by use of brachiopods, the Spirifer Limestone of Svalbard. On the other hand, the Fusulina Limestone of Svalbard was correlated by STAFF, using fusulines, with the true Schwagerina horizon of NIKITIN.

Recent fusulinid studies by FORBES (1958, 1960) have defined the Carboniferous–Permian boundary in Bünsow Land. Further studies on the fusulinids would be very valuable but as they have not been found above the Cyathophyllum Limestone, they can provide only a lower limit to the age of the Spirifer Limestone.

The most abundant fossils in the Spirifer Limestone and Brachiopod Chert are brachiopods and they are at least as common as other fossil groups in the Middle Carboniferous part of the succession. In revising these brachiopods I have taken advantage of recent collecting and of refinements in brachiopod systematics, particularly with regard to the productids. I have refrained from making too close a comparison with Russia or North-West Europe although recent work (FREBOLD 1950, DUNBAR 1955, HARKER and THORSTEINSSON 1960) has enabled comparison of the fauna with that of Greenland and arctic Canada. It is hoped that this study will provide a broader basis for correlation, at least for rocks of Middle Carboniferous and Permian age, both within and without Svalbard.

The palynology of the continental Lower Carboniferous of Svalbard has been studied at Cambridge by Dr. G. PLAYFORD (1962 and 1963); his research should give a precise lower limit to the age of the marine Middle Carboniferous.

The present study was suggested to me by Mr. W. B. HARLAND from his recent consideration of the various faunal lists in the preparation of the paper FORBES, HARLAND, and HUGHES 1958, from his knowledge of the Cambridge material collected on expeditions organized by him, and in the light of plans for his forthcoming expedition in 1959 which I was able to accompany.

II. STRATIGRAPHY

Introduction

The present distribution of Carboniferous and Permian strata in Svalbard is shown in Fig. 1. Over most of their outcrop the rocks are well-exposed on nunataks separated by extensive glaciers and highland ice. Details of local areas, with place names, are shown in Figs. 2–8.

The base of the Carboniferous, wherever seen, lies unconformably on Old Red Sandstone or older (Hecla Hoek) rocks. The pre-Carboniferous surface has a considerable relief in some localities (e. g. in Ebbadalen, Billefjorden, where the Lower Carboniferous Billefjorden Sandstone is banked up against a hill of Hecla Hoek amphibolite); but over large areas (e. g. in Ny Friesland), Carboniferous strata appear to lie on a peneplained surface (W. B. HARLAND, personal communication, and my own observations). The Permian is succeeded disconformably by Eo-Triassic beds (Carnian in Bjørnøya). Apart from disturbance by faulting (e. g. in Billefjorden), the Carboniferous and Permian strata lie nearly horizontally in most areas. On the west coast, Tertiary movements have caused strong folding and overthrusting, the beds usually have a steep dip, and are sometimes overturned as at Reinodden (see above).

The north-south fault zone running through Wijdefjorden and Billefjorden is a major structural feature of Spitsbergen (MCWHAE 1953). The distribution of Old Red Sandstone is limited to the west of this zone and, although the Permian succession on both sides is similar, the Carboniferous stratigraphy on the east differs considerably from that on the west (see below). The succession in the areas to the east of this zone will be discussed first, starting with Bünsow Land where it is probably most continuous. The outcrop will then be traced north-eastwards to Nordaustlandet. To the west of the fault zone it will be traversed to Brøggerhalvøya, south-south-east down the west coast fold belt and finally to Bjørnøya.

In the following outline of the stratigraphy, special reference is made to the occurrence and content of brachiopod faunas.

Inner Isfjorden east of the Wijdefjorden - Billefjorden fault zone (Fig. 2)

The stratigraphy of Bünsow Land was described in detail by GEE *et al.* (1953) and fossil lists were published subsequently (FORBES *et al.* 1958) for the various formations. These lists have been augmented and revised (see below).

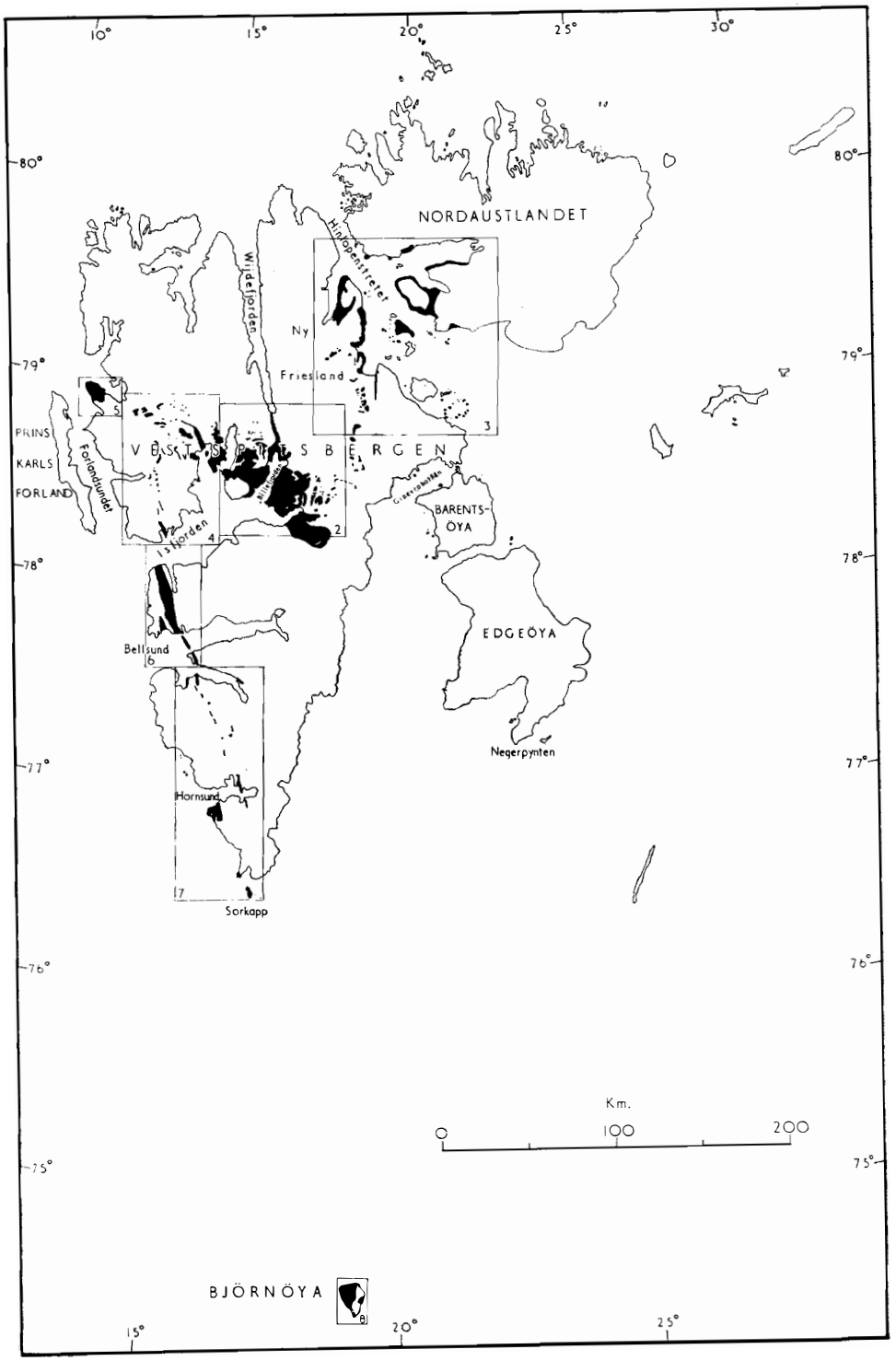

Fig. 1. Map of Svalbard, showing the distribution of Carboniferous and Permian rocks and the areas covered by the locality maps, text figures 2–8.

In Bünsow Land, sedimentation appears to have been almost continuous from early Carboniferous times until the middle Permian. Eo-Triassic strata are not present, but are exposed in the southern part of Dickson Land and to the south of Sassenfjorden. The beds dip generally south-south-west and the upper horizons are exposed only in the south. The succession in Bünsow Land is shown below. This has been modified from the succession given by FORBES *et al.* (1958). The terminal "s" has been omitted from the names "Billefjorden Sandstones", "Wordiekammen Limestones", and "Brachiopod Cherts" given by FORBES *et al.* (1958, table 1, p. 466) and the lowest part of the Campbellryggen Group has been named the Transition Beds. The thicknesses given are approximate.

	Dolerite sill
BRACHIOPOD CHERT (300 m)	*Upper.* Unfossiliferous brown, black, and yellow cherts with glauconitic sandstone near the top. *Middle.* Cherts as above, black silicified limestones, and subordinate siliceous shales. Brachiopods concentrated into thin beds; most of the rock unfossiliferous. *Lower.* Cherts including prominent beds of white unfossiliferous chert, cherty and sandy limestones, generally unfossiliferous. Spirifer Limestone at base.
CYATHOPHYLLUM LIMESTONE (500 m)	Hiatus *Upper Gypsiferous Series.* Gypsum and pale brown, cellular limestones. *Upper Wordiekammen Limestone.* Pale grey, crag-forming limestones. *Mid Wordiekammen Limestone.* Thin, fusuline-rich, flaggy, bituminous limestone. *Lower Wordiekammen Limestone.* Pale grey to black, porcellanous limestones. Massive 'Black Crag' at the base.
CAMPBELLRYGGEN GROUP (400 m)	*Passage Beds.* Black limestones, yellow sandstones, shales and gypsum. *Lower Gypsiferous Series.* White and pink gypsum beds, typically 2–10 m thick, alternating with thin black bituminous limestones. *Transition Beds.* Multicoloured sandstones and shales.
BILLEFJORDEN SANDSTONE (200 m)	White and yellow quartzites, black shales, and coal seams
	Unconformity
HECLA HOEK METAMORPHIC ROCKS	

The Billefjorden Sandstone is a continental deposit and contains plant microfossils of Tournaisian and Viséan age (HUGHES and PLAYFORD 1961). Brachiopods were collected in 1958 from the Transition Beds of Odellfjellet, north of Billefjorden. These comprise *Schuchertella?* sp., *Reticulatia holtedahli* sp. nov., *Linoproductus?* sp. B, *Striatifera?* sp., and a small orthotetid resembling the *Streptorhynchus* sp. described below. At the base of the Lower Gypsiferous Series on the south side of Ebbadalen, thin impure limestones contain *Pustula* cf. *mosquensis* (IVANOV), *Ovatia* cf. *simensis* (TSCHERN.), *Martinia* sp. A, and *Composita ambigua* (SOW.). At the same horizon on De Geerfjellet *Schuchertella?* sp. and *?Antiquatonia* cf. *serenensis* SARYCHEVA were collected. Some of the limestone beds higher in the formation contain *Lingula* sp., *Orbiculoidea* sp. and small, indeterminate *Rhynchonellacea* or *Rhynchospirinidae*. The Passage Beds, into which the Lower Gypsiferous Series passes both vertically and laterally, have a richer brachiopod fauna. This has been collected mainly from Sfinksen, Wordiekammen, Campbellryggen and Minkinfjellet and contains the following species:

Orthotichia cf. *morganiana* (DERBY)
Schuchertella sp.
Buxtonia sp.
Antiquatonia cf. *serenensis* SARYCHEVA
Reticulatia holtedahli sp. nov.
Dictyoclostids spp. indet.
Linoproductus sp. A
Ovatia cf. *simensis* (TSCHERN.)
Laevicamera cf. *arctica* (HOLTEDAHL)
Phricodothyris? sp.
Choristites aliforme sp. nov.
Choristites sp.
Composita ambigua (SOW.)
Spiriferina sp. A
Hustedia? sp. B

These faunas may be broadly equated with those of the Middle Carboniferous of the Moscow Basin.

The Wordiekammen Limestone contains a sparse brachiopod fauna. From the lower division (*Triticites zone*) the following have been collected:

Strophalosiacea sp. indet.
Echinoconchus elegans (M'COY)
Waagenoconcha sp. B
Chaoiella cf. *grünewaldti* (KROTOW)
Linoproductus sp. A
Mesolobus? sp.
Paeckelmannia forbesi sp. nov.
Laevicamera cf. *arctica* (HOLTEDAHL)
'*Spirifer*' sp. indet.

The Mid Wordiekammen Limestone (Fusulina Limestone of some earlier authors) has yielded an indeterminate Dictyoclostid and *Marginifera? schellwieni* TSCHERN. The following brachiopods have been collected from the Upper Wordiekammen Limestone (*Pseudoschwagerina* zone):

Derbyia sp.
Aulosteges sp.
Marginifera? cf. *schellwieni* TSCHERN.

Juresania juresanensis (TSCHERN.)
Chaoiella? cf. *taiyuanfuensis* (GRABAU)
Linoproductus dorotheevi (FREDS.)
Cancrinella singletoni sp. nov.
Paeckelmannia forbesi sp. nov.
Camerotoechia? cf. *krotovi* (TSCHERN.)
Camerotoechia? sp.
Neophricadothyris asiatica (CHAO)
Neospirifer subfasciger? LICHAREW
Neospirifer cf. *tegulatus* (TRAUTSCHOLD)
Cleiothyridina cf. *sibirica* EINOR
Cleiothyridina aff. *maynci* DUNBAR
Composita sp. B
Spiriferina sp. B
Dielasma giganteum TSCHERN.
?Dielasma plica (KUTORGA)

Brachiopods occurring in limestones in the Upper Gypsiferous Series are:

Linoproductus dorotheevi (FREDS.)
Cancrinella singletoni sp. nov.
Cancrinella spitsbergiana sp. no .
Rhynchopora sp.

The Spirifer Limestone is prolific in brachiopods specifically distinct from those occurring in the Cyathophyllum Limestone. The Spirifer Limestone itself (Limestone A of GEE *et al.* 1953) is of varied lithology, consisting of grey or black limestone with variable amounts of chert and clastic material; in places it is a calcareous sandstone. The fossils are frequently silicified; they weather out and may be easily collected. In Bünsow Land 35 species have been collected from the Spirifer Limestone of which the most abundant are:

Streptorhynchus macrocardinalis TOULA
Waagenoconcha irginae (STUCK.)
Costinifera arctica (WHITFIELD)
Horridonia timanica (STUCK.)
Cancrinella spitsbergiana sp. nov.
Yakovlevia impressa (TOULA)
Camerophoria spitzbergiana STEP.
Rhynchopora nikitini TSCHERN.
Spirifer striato-paradoxus TOULA
Spirifer striato-plicatus sp. nov.
Spiriferella polaris (WIMAN)
Spiriferella keilhavii (BUCH)
Cleiothyridina royssiana (KEYS.)
Dielasma plica (KUTORGA)

The Lower Brachiopod Chert above the Spirifer Limestone has a similar, if somewhat reduced fauna. However, some species e. g. *Liosotella pseudohorrida* (WIMAN) and *Megousia weyprechti* (TOULA), which are uncommon in the Spirifer Limestone, become more abundant. Ten Spirifer Limestone species are present in the Middle Brachiopod Chert and to these are added the following:

Krotovia licharewi (FREBOLD)
Liosotella proboscidea sp. nov.
Linoproductus lutkewitschi STEPANOV
Muirwoodia duplex (WIMAN)

Chonetina superba sp. nov.
Camerophoria sp. aff. *spitzbergiana* STEPANOV
Licharewia cf. *grewingki* (NETSCHAJEW)
Spiriferella aff. *interplicata* (ROTHPLETZ)
Pterospirifer cordieri (ROBERT)
Paeckelmannella aff. *expansa* (TSCHERN.)

In Bünsow Land, the Upper Brachiopod Chert yielded no fossils; in the southern part of Dickson Land and in Sassendalen, the inarticulate brachiopods *Lingula freboldi* sp. nov. and *Orbiculoidea winsnesi* sp. nov. are found in glauconitic sandstones near the top of the succession.

North of Billefjorden, a thick development of Billefjorden Sandstone and Campbellryggen Group is present on Odellfjellet and Trikolorfjellet, the latter mountain being capped by Cyathophyllum Limestone. South of Tempelfjorden the succession of the Upper Gypsiferous Series and Brachiopod Chert is similar to that in Bünsow Land. On Marmierfjellet the Brachiopod Chert is about 300 m thick. The following section is summarized from field observations made by the 1959 Cambridge Svalbard Expedition.

25 m	Glauconitic sandstone and yellow chert.
40 m	Black and yellow chert.
100 m	Chert and some glauconitic sandstone with *Megousia weyprechti* (TOULA).
30 m	Shales with polyzoa, in the lower half alternating with thin limestones containing *Spiriferella* aff. *interplicata* (ROTH.) and *Chonetina superba* sp. nov.
100 m	Chert with *Megousia weyprechti* (TOULA) and *Muirwoodia mammata* (KEYS.)
	Spirifer Limestone.

East of Bünsow Land the Billefjorden Sandstone thins rapidly and the Campbellryggen Group is overlapped or replaced by limestones which pass up into the equivalent of the Wordiekammen Limestone. The Upper Gypsiferous Series also appears to be replaced by cellular limestones east of the head of Tempelfjorden. Few detailed sections are known from the thick limestone sequence best referred to as Cyathophyllum Limestone. At station E5 (see Fig. 2) the following section at the base of the Cyathophyllum Limestone was measured by the 1954 Sherborne Spitsbergen Expedition.

	Massive cliff-forming limestone with thin sandstone at the base.
	Scree
6 m	Sandstone, and limestone with corals.
4 m	Scree
15 m	Cliff-forming limestone with a bed of fossiliferous sandy limestone in the middle.
10 m	Scree.
15 m	Porcellanous limestone.
10 m	Sandy limestone with pebbles of Hecla Hoek quartzite and a basal, red limestone breccia of variable thickness.
	Scree-covered unconformity.
	Hecla Hoek rocks.

From the scree of Malte Brunfjellet, this expedition collected species of *Choristites, Linoproductus, Chonetes,* and *"Dictyoclostus"*.

The Spirifer Limestone lies at about 750 m above sea level at the northern end of the Ultunafjella ridge. To the east it is obscure, possibly scree-covered, but typical Spirifer Limestone fossils were collected, by the 1954 expedition mentioned above, from cherts on the northern part of Kolonadene, on the top of Barkowfjellet, on the south-west ridge of Skedvifjella, at station X3, and on the southern summit of Smyslovfjellet.

The area around Hinlopenstretet (Fig. 3)

In the south-east part of Ny Friesland, Carboniferous and Permian rocks are faulted against the Hecla Hoek. To the east of this fault is an inlier of Hecla Hoek overlain by eastwardly dipping Carboniferous. South of the inlier the base of the Carboniferous is not seen but Pachtusovfjellet exposes 250 m of grey limestone, the upper part of which contains *Rhipidomella?* sp., *Laevicamera* cf. *arctica* (HOLTEDAHL), and *Choristites* sp.

At the mouth of Oslobreen, on Ditlovtoppen and station W139, the Lower Carboniferous (Culm) succession comprises about 10 m of red conglomeratic sandstone overlain by scree containing black shale. Microspores recovered from this shale are probably uppermost Viséan or perhaps lowest Namurian in age (G. PLAYFORD, personal communication). Above the scree are grey, crag-forming, cherty limestones with corals and crinoid fragments, *Meekella* cf. *timanica* (TSCHERN.) and *Derbyia* sp. Higher parts of the succession are seen on Komarovfjellet, where about 250 m of limestones are overlain by sandy limestones with *Waagenoconcha irginae?* (STUCK.), *Horridonia timanica* (STUCK.), *Cancrinella tenuissima* sp. nov., *Megousia weyprechti* (TOULA), *Neospirifer* cf. *fasciger* (KEYS.), *Spiriferella polaris* (WIMAN), and *Cleiothyridina royssiana* (KEYS.).

At the mouth of Chydeniusbreen a similar succession is present. Sections were measured, by the 1951 Cambridge Spitsbergen Expedition, on Cepheusfjellet, Mertonberget, and station B 30, and from these the following sequence may be deduced.

	Probable equivalents in Bünsow Land
12. Cherts and subordinate limestones with *Liosotella pseudohorrida* (WIMAN), *Waagenconcha* cf. *irginae* (STUCK.), *Waagenoconcha* sp., *Costinifera arctica?* (WHIT.), *Horridonia timanica* (STUCK.), *Anidanthus aagardi* (TOULA), *Megousia weyprechti* (TOULA), *Muirwoodia duplex* (WIMAN), *Moniticulifera? lovéni* (WIMAN), *?Paeckelmannia capitolina* (TOULA), *Lissochonetes spitzbergianus* (TOULA), *Licharewia wimani* nom. nov., *Licharewia* cf. *grewingki* (NETSCH.), *Spiriferella* aff.	BRACHIOPOD CHERT

	interplicata (ROTHPLETZ), *Spiriferella draschei?* (TOULA), *Cleiothyridina kotlukovi* STEP.	115 m	BRACHIOPOD CHERT
11.	Spirifer Limestone with *Horridonia timanica* (STUCK.), *Cancrinella spitsbergiana* sp. nov., *Spirifer* cf. *poststriatus* NIKITIN, *Licharewia spitsbergiana* sp. nov.	5 m	
10.	Scree-covered limestone with some chert.	30 m	CYATHOPHYLLUM LIMESTONE
9.	Crag-forming limestone with *Cancrinella singletoni* sp. nov., and *Composita* sp. B.	10 m	
8.	Crag-forming limestone breccia	60 m	
7.	Scree-covered sandy limestone with *Paeckelmannia forbesi* sp. nov.	80 m	
6.	Recrystallized cellular limestone with small blue cherts and *?Camerophoria* cf. *krotovi* (TSCHERN.)	20 m	
5.	Limestone scree.	30 m	
4.	Crinoidal and fusuline limestone.	10 m	
3.	Massive crag-forming limestone with chert, corals, indeterminate Productids and Spiriferids, *?Echinoconchus isachseni* HOLTEDAHL. Basal bed of corals.	80 m	CAMPBELLRYGGEN GROUP
2.	Scree with black shale and black porcellanous limestone etc.	20 m	
1.	Red conglomeratic sandstone	10–20 m	BILLEFJORDEN SANDSTONE

4. 3 m. Grey, cherty limestone with white chert or silicified limestone. Fossils abundant, including *Kochiproductus porrectus* (KUT.).
   40 m. Snow and ice.
3. 6 m. Grey, calcareous sandstone interbedded with fossiliferous sandstone, including *Horridonia timanica* (STUCK.)
2. 3 m. Cherty limestone.
1. 20 m. Grey crinoidal and sandy limestone with *Linoproductus* aff. *cora* (D'ORB.) (Base not seen).

Divisions 1–3 are seen on station B 30, 4–7 on Cepheusfjellet, and the rest of the sequence on Cepheusfjellet and Mertonberget.

The Hecla Hoek inlier is terminated on the west by a faulted wedge of Permian rocks. At stations G 859 and G 860 the latter consists of about 50 m of grey limestones overlain by 10 m of Spirifer Limestone and 25 m of Brachiopod Chert. Part of this sequence is metamorphosed by a thick dolerite sill which at station G 860 lies at about the horizon of the Spirifer Limestone.

Farther north in Lomfjordhalvøya, the 19th century Swedish expeditions collected brachiopods, exceptionally well preserved in white chert, from Lovénberget. These are typical Brachiopod Chert fossils and include examples of *Monticulifera? lovéni* (WIMAN) and *Licharewia wimani* nom. nov.

In Nordaustlandet few sections have been studied. At Ulvebukta, C. S. ELTON (in SANDFORD 1926, p. 639) recorded a section which is here condensed as follows:

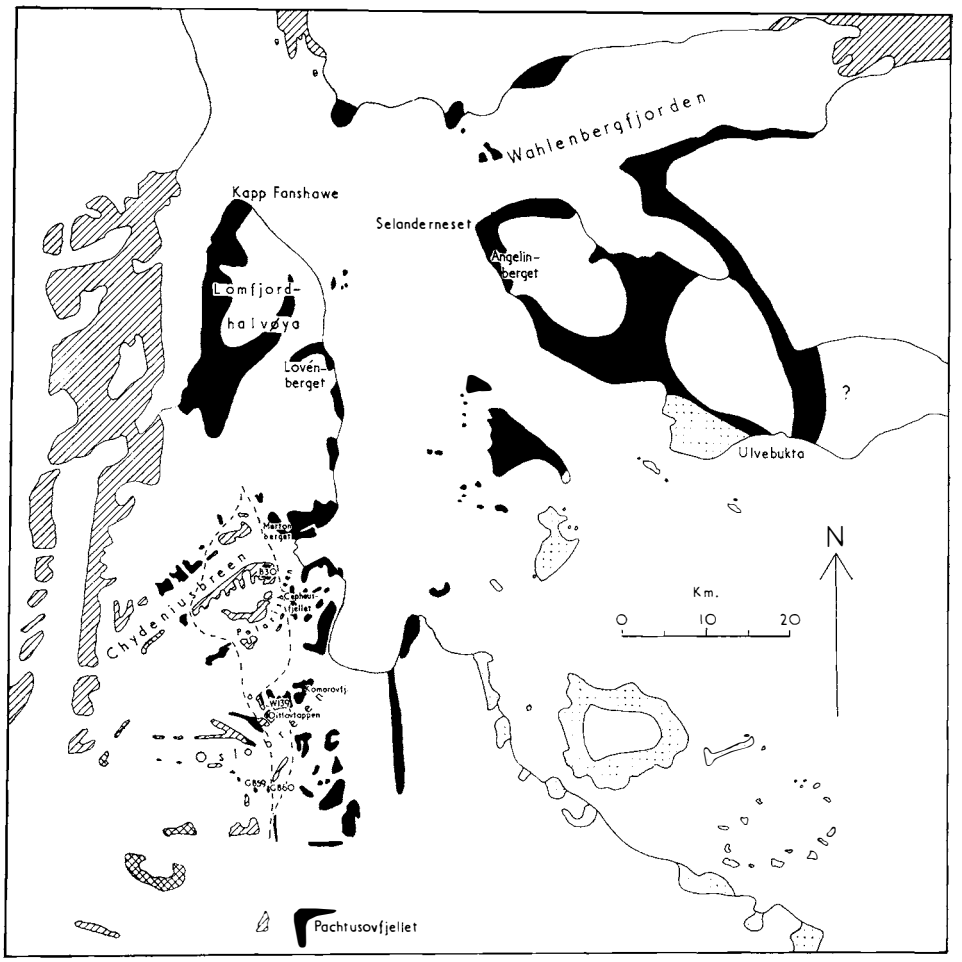

Fig. 3. Hinlopenstretet. Geology simplified after SANDFORD (1926), ORVIN (1940), and WILSON (1958).

Black	Carboniferous and Permian
Oblique lines	Hecla Hoek
Crossed lines	Granite
Dots	Mesozoic
Blank	Ice

Broken lines bounds the Hecla Hoek inlier.

SANDFORD equated bed 4 with the Spirifer Limestone and the underlying beds with the Upper Gypsiferous Series. The presence of *H. timanica* in bed 3, however, suggests that this also belongs to the Spirifer Limestone. Bed 1 could be equivalent to the upper part of the Cyathophyllum Limestone.

Chert beds, partly metamorphosed by dolerite, occur on both sides of Wahlenbergfjorden; and according to DE GEER (see SANDFORD 1926, p. 643) about 40 m of Spirifer Limestone at Selanderneset are overlain by 100 m. of "Productus Beds". On Angelinberget the Brachiopod Chert contains *Paeckelmannia* cf. *permiana* (SCHUMARD), *Licharewia wimani* nom. nov., *Paeckelmannella* aff. *expansa* (TSCHERN.), and *Dielasma tschernyscheffi* (GRABAU).

Inner Isfjorden west of the Wijdefjorden-Billefjorden fault zone (Figs. 2 and 4)

The Carboniferous succession exposed west of Billefjorden differs from that of Bünsow Land. On Pyramiden, the Billefjorden Sandstone is overlain by gypsum beds succeeded by 75–300 m of red conglomerate and sandstones forming the Pyramiden Conglomerate (LUTKEVICH 1937). This formation was correlated with the Passage Beds of Bünsow Land by GEE *et al.* (1953). Productids were collected by the 1959 Cambridge Svalbard Expedition from the Pyramiden Conglomerate south of Mimerbukta, but they are too poorly preserved to be used for correlation.

The top of Pyramiden appears to consist of crag-forming Cyathophyllum Limestone but the Norwegian collections in Oslo contain typical weathered blocks of Spirifer Limestone obtained by HOEL from the summit. It is possible that a thin capping of Spirifer Limestone lies unconformably on the Cyathophyllum Limestone, which has been reduced in thickness by local penecontemporaneous erosion in the fault zone.

To the north and north-west of Pyramiden, the Campbellryggen Group is absent and the Billefjorden Sandstone on Birger Johnsonfjellet, Citadellet, and Triungen is overlain abruptly by massive, crag-forming limestone. The Billefjorden Sandstone and the Campbellryggen Group are absent south-west of Mimerdalen, around Dicksonfjorden, and Ekmanfjorden, and in James I Land. In these areas the Old Red Sandstone is succeeded unconformably by massive, grey limestones of the Cyathophyllum Limestone. The base of the limestone is frequently conglomeratic and, on Tre Kroner, consists of a few metres of sandstone and conglomerate (HOLTEDAHL 1913, p. 22). A bituminous, fusuline-rich bed is present about 100 m from the base of the limestone on Dronningfjella (HOLTEDAHL 1913, p. 20), on Gangerolvfjella (1959 Cambridge Svalbard Expedition), and north of Kapp Wærn. At the last locality it contains fusulines also present in the Mid Wordiekammen Limestone of Bünsow Land (BATES and SCHWARZACHER 1958, p. 232). The upper part of the Cyathophyllum Limestone (about 300 m thick) is dolomitic and gypsiferous. Beds of gypsum are present on Gangerolvfjella and north of Kapp Wærn, but farther west the amount of gypsum is reduced and cellular dolomites and limestones predominate. In Kongsvegen, the members of the 1960 Durham Spitsbergen Expedition observed that the succession was repeated in a series of thrust sheets. On Colletthøgda and Garwoodtoppen they recorded 200 m of massive limestone overlain by about 200 m of dolomite and limestone, with highly contorted bedding resembling slump-bedding, followed by 60 m of evaporites. Above the evaporites were 20 m of chert and limestone. This was succeeded by 30 m of Brachiopod Limestone, correlated with the Spirifer Limestone, and 150 m of Brachiopod Chert. On Dronningfjella and Tre Kroner the contorted beds and the evaporites were reported absent, 350 m of Cyathophyllum Limestone being succeeded by the Brachiopod Chert. The brachiopods collected by the expedition include a few specimens from the Cyathophyllum Limestone. These are *Krotovia?* sp., *?Chaoiella* cf. *taiyuanfuensis* (CHAO), *Choristites* sp. and *Spiriferina* sp. The bulk of the collection was from the Brachiopod Limestone and includes the following species:

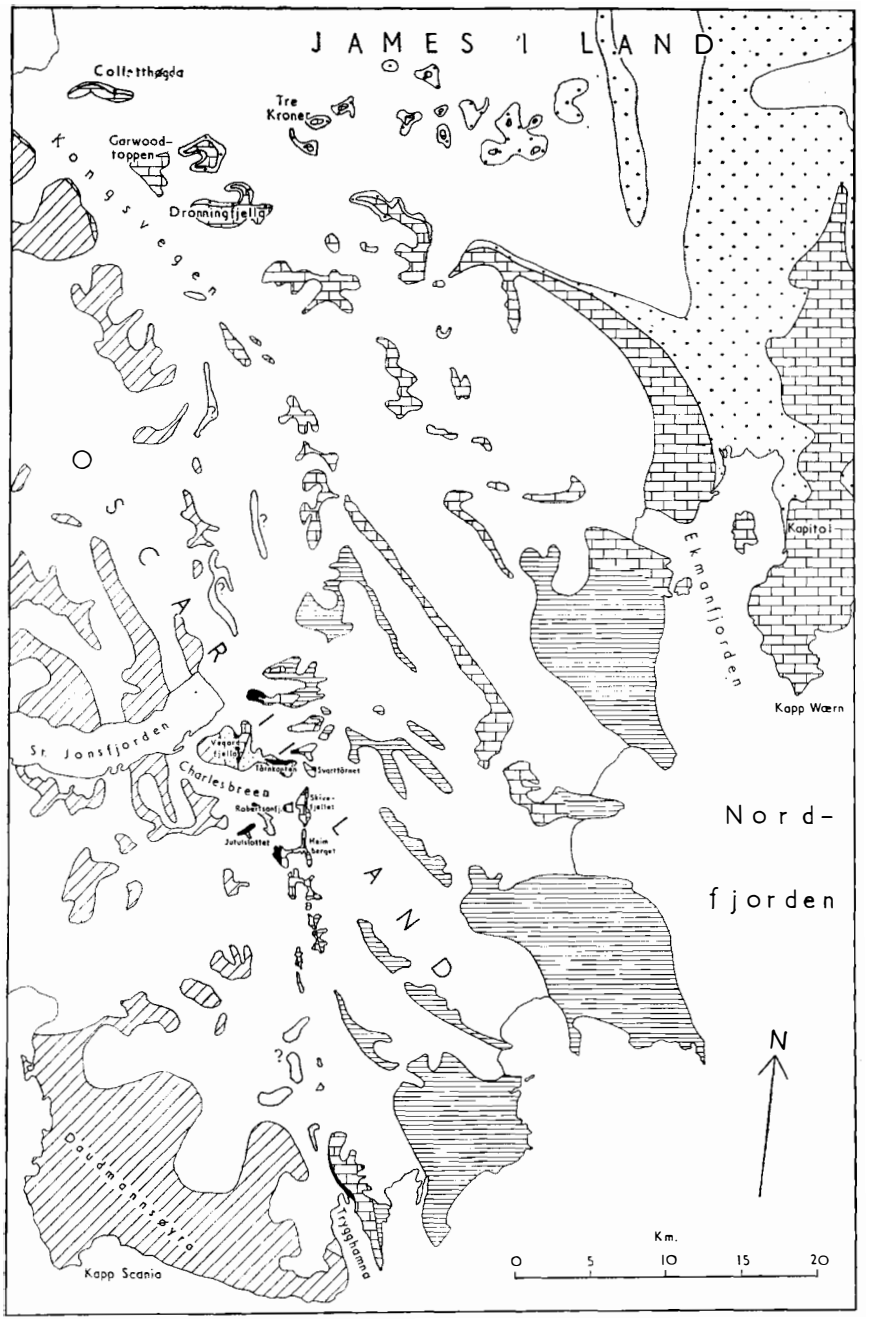

Fig. 4. Oscar II Land. Geology simplified after HOLTEDAHL (1913), ORVIN (1940), DINELEY (1958), BATES and SCHWARZACHER (1958), and GARRET and DINELEY MS.

Oblique lines	Hecla Hoek
Coarse dots	Old Red Sandstone
Fine dots	Culm
Black	Charlesbreen Group
Bricks	Cyathophyllum Limestone
	Brachiopod Chert
Horizontal lines	Mesozoic
Blank	Ice

Liosotella pseudohorrida (WIMAN), *Bathymyonia?* sp., *Waagenoconcha wimani* (FREDS.), *Megousia harlandi* sp. nov., *Muirwoodia duplex* (WIMAN), *Chonetina superba* sp. nov., ? *Camerophoria* cf. *mutabilis* (TSCHERN.), *Spirifer striato-paradoxus* TOULA, *Spiriferella* aff. *interplicata* (ROTH.), *Paeckelmannella* aff. *expansa* (TSCHERN.). This fauna is typical of the Middle Brachiopod Chert of Bünsow Land. The Spirifer Limestone was not recognized in James I Land by HOLTEDAHL (1913); it may be represented by a chert facies as suggested by BATES and SCHWARZACHER (1958).

At Kapp Wijk the Spirifer Limestone is well developed and the following brachiopods were collected there by the 1959 Cambridge Svalbard Expedition: *Liosotella pseudohorrida* (WIMAN), *Waagenoconcha irginae* (STUCK.), *Horridonia timanica* (STUCK.), *Chonetina* sp., *Paeckelmannia capitolina* (TOULA), *Pseudosyrinx wimani* sp. nov., and *Dielasma plica* (KUT.).

Brachiopods from the Brachiopod Chert north of Kapp Wærn were described by TOULA (1875 a). In the southern part of Dickson Land the Brachiopod Chert is exposed along the coast on either side of Rundodden. In 1959 the following section was noted:

	Eo-Triassic shales
8 m.	Pale, cherty sandstone
12 m.	Dark, glauconitic sandstone with *Lingula freboldi* sp. nov.
4 m.	Pale, glauconitic sandstone with chert and *Lingula freboldi* sp. nov.
5 m.	Dark chert with large chert concretions enveloped in shaley partings.
5 m.	Rubbly chert.
4 m.	Black, silicified limestone with pyrite.
c.35 m.	Rubbly, siliceous limestone and chert with shale partings.
1.5 m.	Coarse, brown-weathering sandstone with *Lingula* sp.
c.20 m.	Unexposed: (black chert and shale with polyzoa and brachiopods inland).
2 m.	Chert.
0.5 m.	Dark limestone with *Megousia weyprechti* (TOULA), *Muirwoodia duplex* (WIMAN), and *Cleiothyridina kotlukovi* STEP.
14 m.	Dark chert and sandstone with a 3 m bed of white chert.
14 m.	Concretionary, grey chert and pale sandstone with thin lenses crowded with poorly preserved brachiopods.
8 m.	Black chert and silicified limestone.
80 m.	Unexposed.
10 m.	Spirifer Limestone.
223 m.	

Brøggerhalvøya (Fig. 5)

Thick continental sandstones, probably the equivalent of the Billefjorden sandstone and conveniently termed Culm, occur west of Kiærfjellet, but in the eastern part of Brøggerhalvøya the marine Carboniferous overlies Old Red Sandstone. Below Kiærfjellet and between the Culm and the Cyathophyllum Limestone is at least 10 m of red and grey conglomerate succeeded by 5–10 m of limestone

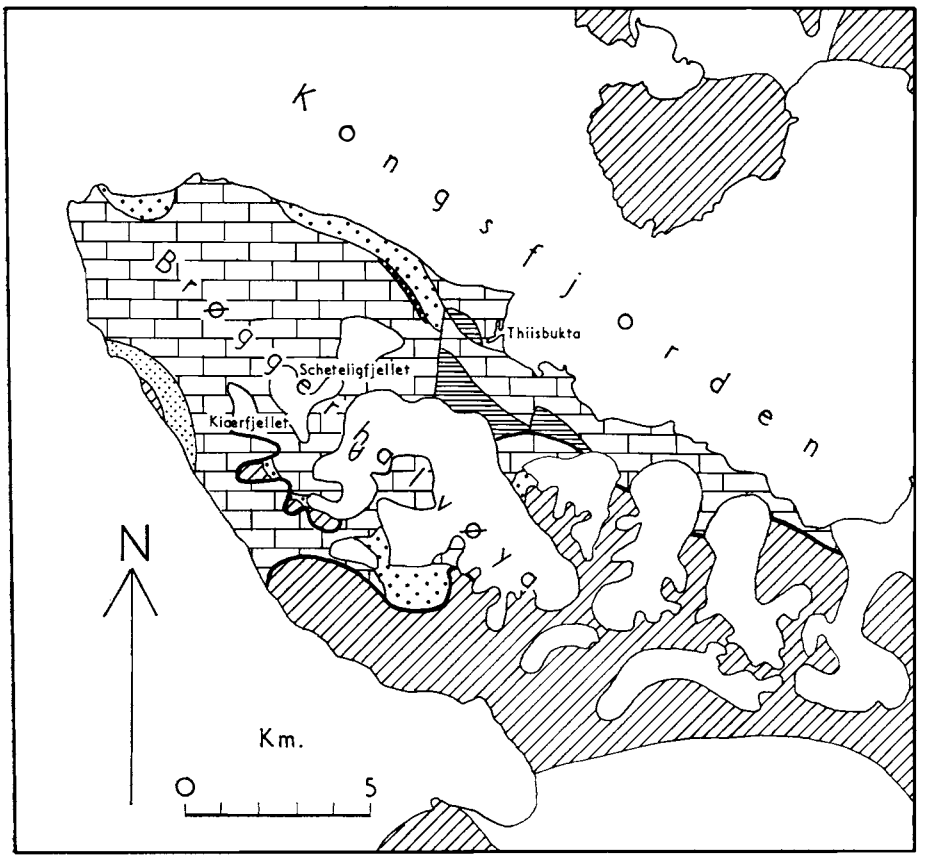

Fig. 5. Brøggerhalvøya. Geology simplified after ORVIN (1934).

Oblique lines	Hecla Hoek
Coarse dots	Old Red Sandstone
Fine dots	Culm
Black with white dots	Scheteligfjellet Beds
Bricks	Cyathophyllum Limestone and Brachiopod Chert
Horizontal lines	Tertiary
Blank	Ice
Thick black lines	Thrusts

with corals, shales. These last correlate with 1.5 m of limestone with a rich brachiopod fauna described by HOLTEDAHL (1911) from the north-east slope of Scheteligfjellet. These Middle Carboniferous beds are here termed the Scheteligfjellet Beds. HOLTEDAHL correlated them with the Moscovian of the U. S. S. R. Revised determinations of the brachiopods are as follows:

HOLTEDAHL, 1911, revised determinations based on specimens extant in the Palaeontological Museum, Oslo.

Rhipidomella michelini (L'ÉVEILLÉ)	*idem.*
Orthis (*Rhipidomella?*)	sp. indet.
Schizophoria indiga WAAGEN	*?Rhipidomella michelini* (L'ÉVEILLÉ)
S. cf. *juresanensis* TSCHERN.	indet.

Orthotichia morgani (DERBY)	*Orthotichia* cf. *morganiana* (DERBY)
Streptorhynchus pelargonatus (SCHLOTH.)	*Streptorhynchus* sp.
Meekella eximia EICHWALD	*?Meekella eximia* EICHWALD
Productus pustulatus KEYS.	*Krotovia* cf. *pustulata* (KEYS.)
P. cf. *wallacei* DERBY	*Krotovia* cf. *wallacei* (TSCHERN.)
P. longispinus SOW.	*?Eomarginifera longispina* (SOW.)
P. punctatus MARTIN	*Echinoconchus punctatus* (SOW.)
P. elegans M'COY	*Echinoconchus? isachseni* (HOLT.)
P. isachseni sp. nov.	*Echinoconchus? isachseni* (HOLT.)
P. cf. *fasciatus* KUT.	*Echinoconchus? isachseni* (HOLT.)
P. irginae STUCK.	*Echinoconchus? isachseni* (HOLT.)
P. boliviensis D'ORB.	Dictyoclostid sp. indet.
P. cora D'ORB.	*Linoproductus* sp. indet.
Camerophoria purdoni DAV.	*Camerophoria* sp. indet.
C. pentameroides TSCHERN.	*Laevicamera* cf. *arctica* (HOLT.)
Reticularia lineata (MART.)	not seen.
Spirifer fasciger KEYS.	*Spirifer* sp. indet.
S. mosquensis FISCHER	*Choristites aliforme* sp. nov.
Spiriferina holzapfeli TSCHERN.	*?Brachythyris* sp.
S. insculpta PHILL.	*Spiriferina* sp. A.
?Eumetria vera HALL.	*Eumetria?* sp. indet.
Dielasma sacculus (MART.)	*Dielasma* sp. indet.
Dielasma spp.	*Dielasma* spp. indet.

This Middle Carboniferous fauna resembles that of the Passage Beds of Bünsow Land and that of the Tårnkanten Sandstone (see below).

The Spirifer Limestone has not been recorded from Brøggerhalvøya: it may be silicified and not differentiated from the chert above.

Oscar II Land (Fig. 4)

HOLTEDAHL (1913) noted that the Culm in inner St. Jonsfjorden was succeeded by a coarse conglomerate containing limestone beds with brachiopods similar to those in the Middle Carboniferous of Brøggerhalvøya. In 1954, the Birmingham Spitsbergen Expedition collected Carboniferous and Permian brachiopods from Oscar II Land. The succession recorded by the expedition (DINELEY 1958) was as follows:

Eo-Triassic shales

240 m. Brachiopod Chert with Brachiopod Limestone at the base.

220 m. Cyathophyllum Limestone. { Gypsiferous Beds / Cellular Limestone / Fusulina Limestone

440 m. Charlesbreen Group. { Tårnkanten Sandstone / Petrelskardet Shales (privately communicated)

125 m. Vegard Sandstone

200 m. Trygghamna Formation.

unconformity

HECLA HOEK

The following brachiopods were collected from thin, impure limestones and black shales within the Tårnkanten Sandstone: *Rhipidomella michelini* (L'ÉVEILLÉ), *Orthotichia* cf. *morganiana* (DERBY), *Schuchertella* cf. *rovnensis* JANISCHEWSKI, *Sinuatella sinuata* (DE KONINCK), *Eomarginifera longispina* (SOW.), *Echinoconchus punctatus* (SOW.), *Echinoconchus elegans* (M'COY), *Buxtonia* sp., *Antiquatonia prikschiana* (YANISCHEVSKY), *Antiquatonia* cf. *serenensis* SARYCHEVA, *Pugilis* sp., *Ovatia simensis?* (TSCHERN.), *Brachythyrina arctica* sp. nov., *Choristites aliforme* sp. nov., *Composita ambigua* (SOW.). This fauna resembles that of the Passage Beds of Bünsow Land.

No brachiopods were collected from the Cyathophyllum Limestone of Oscar II Land. However, collections from the Brachiopod Limestone and Chert contain brachiopods typical of the Lower and Middle Brachiopod Chert of Bünsow Land.

Highly deformed and metamorphosed wedges of Upper Palaeozoic rocks are preserved in the Hecla Hoek on both sides of Forlandsundet. LEE (1908) described the following brachiopods which were collected by BRUCE in 1906 and 1907 from Prins Karls Forland: ? *Orthotetes* or *Derbyia* sp. indet.; ? *Reticularia lineata* (MARTIN); *Marginifera* sp. indet.; *Productus horridus* SOW. [probably *Horridonia timanica* (STUCK.)]; *Productus* cf. *leplayi* VERN. [? *Muirwoodia duplex* (WIMAN)]; *Productus* sp. indet; cf. *Strophalosia leplayi* GEINITZ; and indeterminate Rhychonellids. BAKER *et al.* (1952) recorded *Choristites* sp. from Kapp Scania, Daudmannsøyra.

The west coast from Kapp Starostin to Sørkappøya

(Figs. 6 and 7)

Carboniferous and Permian rocks form a narrow, tightly folded outcrop from Kapp Starostin almost to Sørkapp. Faulted outcrops occur to the west of this strip, notably at Sørkappøya.

The coastal section near Kapp Starostin exposes the Brachiopod Chert in a continuous section (HOEL and ORVIN 1937). The brachiopods described by FREBOLD (1937) from 23 horizons facilitate a three-fold division of the section (FORBES *et al.* 1958, p. 481). However, these three groups of species are based on collections which are small and poorly-preserved in comparison with those from inner Isfjorden. Extensive collecting from the Brachiopod Chert, including the Spirifer Limestone, shows that the brachiopod fauna of this formation is essentially uniform.

The lower part of the sequence, exposed in Orustdalen and Linnédalen (HOLTEDAHL 1913), consists of thick Culm overlain by thin conglomerates, sandstones and shales, in turn followed by about 350 m of Cyathophyllum Limestone with a fusuline-rich bed near the base. STEPANOV (1937 a) described brachiopods from the Brachiopod Chert of Kapp Starostin and Kongressdalen. These included *Linoproductus lutkewitschi* STEP.; *Megousia* cf. *kulikii* (FREDS.); *Muirwoodia mammata* (KEYS.); *Camerophoria spitzbergiana* STEP.; *Paeckelmannella* aff. *expansa* (TSCHERN.) [described as *Spiriferina wimani* nom. nov.]; *Pterospirifer cordieri* (ROBERT) [described as *Cyrtospirifer? kharaulkensis* FREDS.]; *Pseudosyrinx? arcticus* (WHIT.); and *Cleiothyridina kotlukovi* STEP.

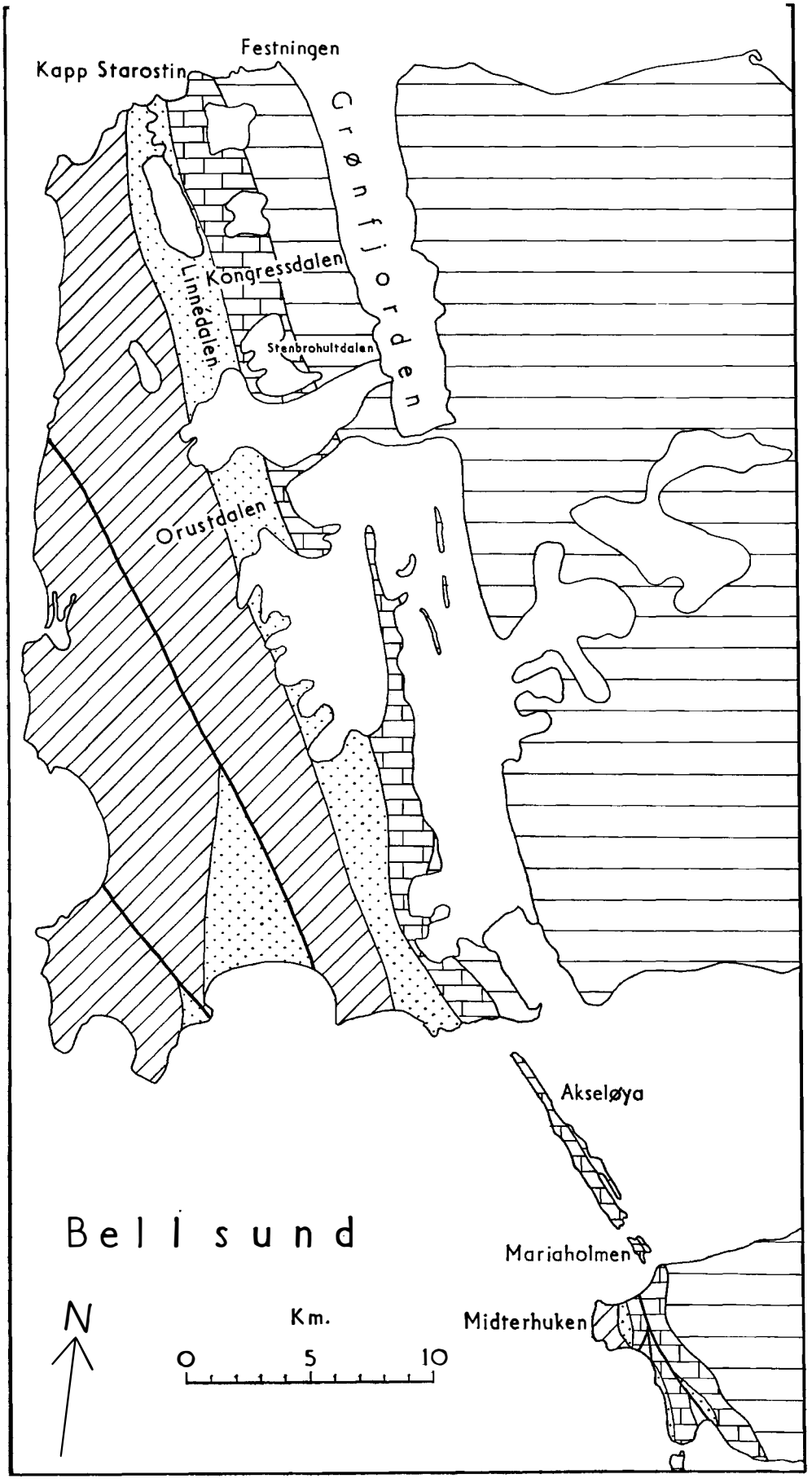
Festningen
Kapp Starostin
Crønfjorden
Kongressdalen
Linnédalen
Stenbrohultdalen
Orustdalen
Akseløya
Bellsund
Mariaholmen
Midterhuken
N
Km.
0
5
10

Fig. 6.

In Bellsund the Culm, Cyathophyllum Limestone, and Brachiopod Chert are recognized but the stratigraphy has not been investigated in detail. Brachiopods have been collected only from the Brachiopod Chert and mainly from Akseløya (TOULA 1875 c, WIMAN 1914). The sections at Reinodden and Ahlstrandodden have been described by ORVIN (1940) and DINELEY (1958). WINSNES has collected brachiopods from the Brachiopod Chert of these localities. They are species common in the Middle Brachiopod Chert of Bünsow Land e. g. *Liosotella pseudohorrida* (WIMAN), *Muirwoodia duplex* (WIMAN), *Spiriferella* aff. *interplicata* (ROTH.), *Paeckelmannella* aff. *expansa* (TSCHERN.), and *Cleiothyridina kotlukovi* STEP.

The geology of the land south of Van Keulenfjorden was investigated by the Polish 1934 Expedition and described by RÓZYCKI (1959). The outcrop of Carboniferous and Permian rocks is continuous with that farther north and clearly displays strong Tertiary overfolding and thrusting. RÓZYCKI delineated four overthrust folds trending north-north-west. As at Reinodden, the Supanberget fold contains 200 m of red and green conglomerates, sandstones and shales lying stratigraphically above the Culm, and passing by vertical transition into the Cyathophyllum Limestone. In the Berzeliustinden (Ahlstrandodden) and Saussureberget folds the Culm is succeeded directly by Cyathophyllum Limestone without trace of an unconformity. The Brachiopod Chert with the Spirifer Limestone at the base is about 400 m thick and uniform over the whole area.

The Carboniferous and Permian outcrops between Kopernikusfjellet and Adriabukta were investigated by BIRKENMAJER (BIRKENMAJER and CZARNIECKI 1960). In Adriabukta, the south face of Hyrnefjellet shows about 270 m of red conglomerates, sandstones and shales, the Hyrnefjellet Beds, lying stratigraphically above the Culm. Succeeding these are about 150 m of Treskelodden Beds, consisting of sandstones and shales alternating with conglomerates and containing five limestone horizons. The Hyrnefjellet Beds are unfossiliferous but the upper two limestone horizons of the Treskelodden Beds yielded brachiopods as follows: (BIRKENMAJER and CZARNIECKI 1960, p. 204):

5th limestone horizon; *Buxtonia juresanensis* (TSCHERN.)
4th limestone horizon; *Krotovia pseudoaculeatus* (KROT.),
Echinoconchus fasciatus (KUT.), *Camerophoria* cf.
multiplicata DAV., *Phricodothyris asiatica* (CHAO), and *Spirifer* sp.

This fauna shows a similarity with that of the Upper Wordiekammen Limestone of Bünsow Land. In 1960 CZARNIECKI made further collections from these beds.

Fig. 6. Festningen to Bellsund. Geology simplified after HOLTEDAHL (1913) and ORVIN (1940).

Oblique lines	Hecla Hoek
Dots	Culm
Bricks	Cyathophyllum Limestone and Brachiopod Chert
Horizontal lines	Mesozoic
Blank	Ice
Thick black lines	Faults

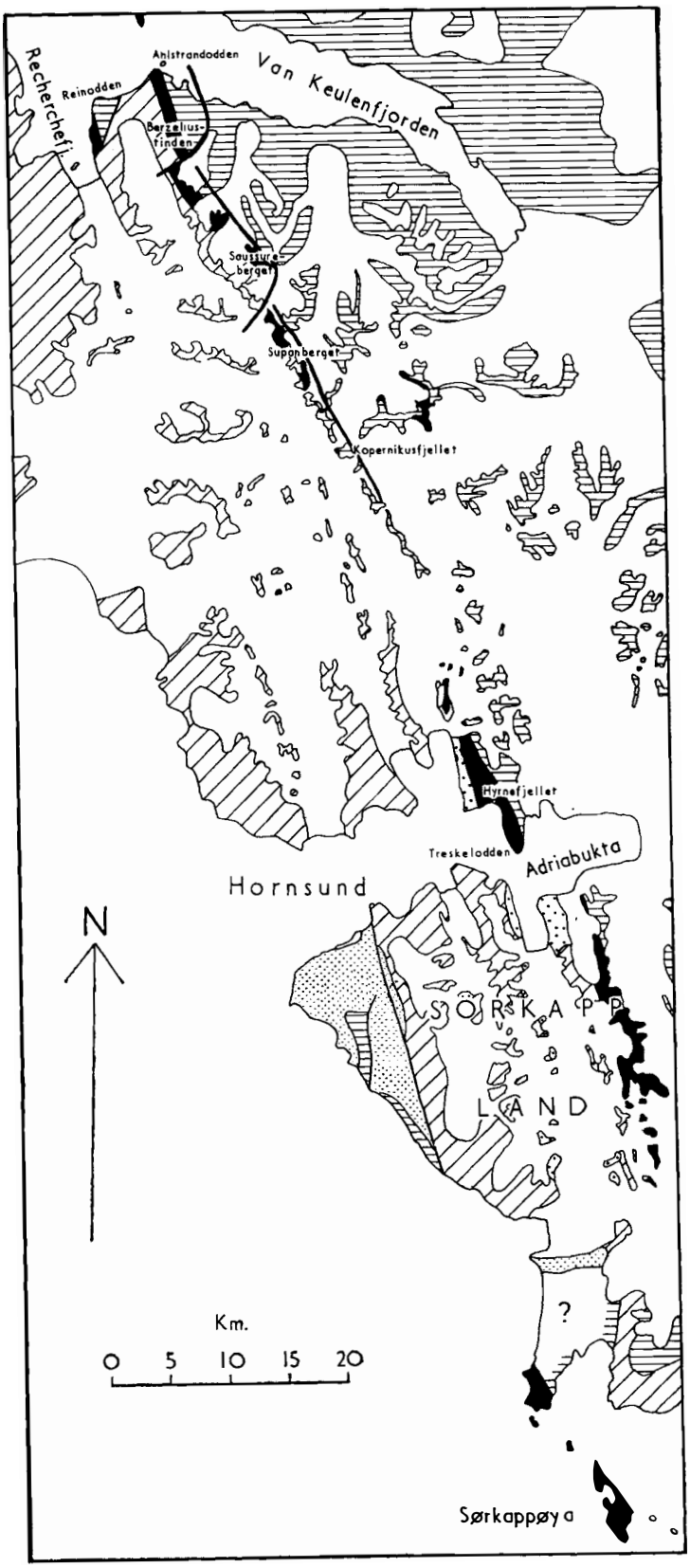
Recherchefj.
Reinodden
Anistrandodden
Van Keulenfjorden
Berzeliustinden
Saussurebergen
Suponbergen
Kopernikusfjellet
Hyrnefjellet
Treskelodden
Adriabukta
Hornsund
N
SØRKAPP
LAND
Km.
0 5 10 15 20
?
Sørkappøya

Fig. 7.

On Kopernikusfjellet, the Hyrnefjellet and Treskelodden Beds total only 60–70 m and are followed by 200 m of Cancrinella Limestone with abundant *Cancrinella koninckiana* (VERN.). Limestones on Svartperla, referred by BIRKENMAJER to the Cyathophyllum Limestone, are about 200 m thick and are overlain by 50 m of cherty limestone: no brachiopods were recorded from these beds. The Brachiopod Cherty Limestone lies disconformably on the Treskelodden Beds at Treskelodden and on the Cancrinella Limestone on Kopernikusfjellet.

The brachiopods from Hornsund described by TOULA (1875 a) were probably all collected from the Brachiopod Cherty Limestone. CZARNIECKI is preparing a full description of the brachiopods from the Hornsund area. BIRKENMAJER and CZARNIECKI (1960) list 27 species from the Brachiopod Cherty Limestone, including *Liosotella? wilczeki* (TOULA), *Martinia* cf. *corcolum* (KUT.), *Pterospirifer alatus* (SCHLOTH.), *Spirolytha magna* MILORADOVICH, and *Spiriferina* cf. *cristata* (SCHLOTH). These species suggest that it is equivalent to the higher horizons of the Isfjorden Brachiopod Chert or is possibly younger.

In north-west Sørkapp Land SIEDLECKI (1960) has shown that most of the Carboniferous and Permian succession is missing, the Eo-Triassic resting on the Culm. It is probably present in the central part of Sørkapp Land but no work has been published on the area. The Brachiopod Chert is exposed on Sørkappøya and typical Brachiopod Chert fossils were described from there by TOULA (1874) and FREBOLD (1937).

Bjørnøya (Fig. 8)

The stratigraphy of Bjørnøya was first elucidated by ANDERSSON (1900), see introduction. The "Ursa Stufe" (Ursa Sandstone) was studied in more detail by HORN and ORVIN (1928) but, apart from brief accounts by these authors and HOLTEDAHL (1920), the marine Carboniferous and Permian strata remained relatively poorly known.

The 1959 Cambridge Svalbard Expedition included a party on Bjørnøya who collected brachiopods from this part of the sequence and recorded the following sections.

Fig. 7. Bellsund to Sørkapp. Geology simplified after ORVIN (1940), MAJOR and WINSNES (1955), ROZYCKI (1958), and BIRKENMAJER and CZARNIECKI (1960).

Oblique lines ..... Hecla Hoek
Coarse dots ..... Old Red Sandstone
Fine dots ..... Culm, where differentiated
Black ..... Carboniferous and Permian
Horizontal lines ..... Mesozoic and Tertiary
Blank ..... Ice

Thick black lines delimit the Berzeliustinden, Saussureberget, and Supanberget overfolds.

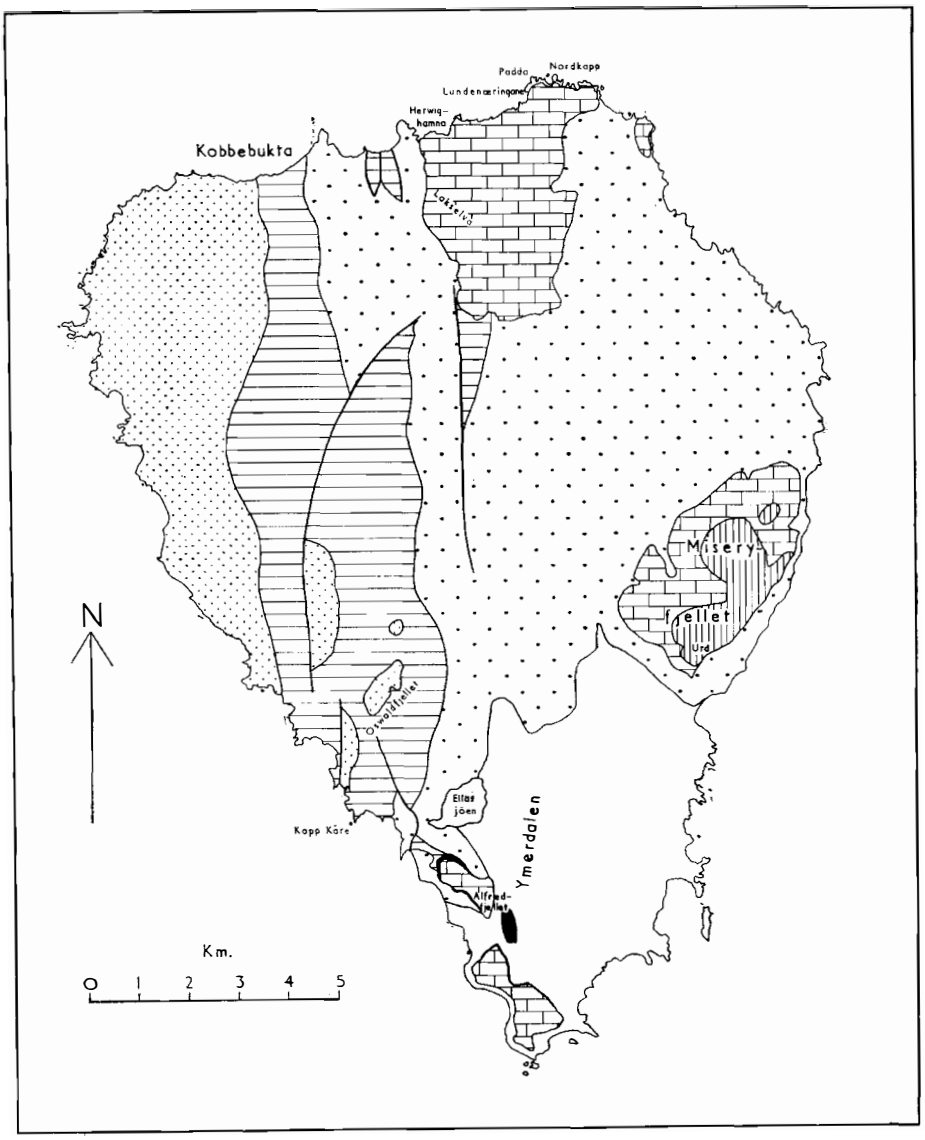

Fig. 8. Bjørnøya. Geology simplified after HORN and ORVIN (1928).

Blank	Hecla Hoek
Coarse dots	Ursa Sandstone
Horizontal lines	Red Conglomerates, Ambigua Limestone and Yellow Sandstone.
Fine dots	Fusulina Limestone
Black	Cora Limestone
Bricks	Spirifer Limestone
Vertical lines	Trias
Thick black lines	Faults

In Kobbebukta four sections were measured which may be summarized as follows:

YELLOW SANDSTONE	20 m.	Conglomerate and sandstone.
	4 m.	Limestone conglomerate with *Linoproductus* sp. indet.
	1 m.	Soft, grey and red limestone with abundant *Composita ambigua* (SOW.).
AMBIGUA		Fault
	10 m+.	Interbedded red shales and grey limestones *Dictyoclostus pinguis* MUIR-WOOD, *?Choristites* sp., and *?Brachythyris* sp.
LIMESTONE		Fault
	50 m+.	Interbedded black shale, black and grey limestone and grey sandstone with *Schuchertella* sp., *?Reticulatia holtedahli* sp. nov. and *Brachythyrina* sp.
		Fault

North of Kapp Kåre the following section was measured in the Ambigua Limestone:

3 m+.	Pale grey and buff conglomerate of quartz and limestone pebbles with *Echinoconchus? isachseni* (HOLT.).
3 m.	Grey limestone with *Krotovia* sp., *?Eomarginifera longispina* (SOW.), *Dictyoclostus* cf. *inflatiformis* IVANOV, *Linoproductus* sp. A, *Choristites aliforme?* sp. nov., *Composita ambigua* (SOW.).
5 m+.	Pale grey and pink limestone with corals.

The landslip in Ymerdalen provided the best exposure of the Cora Limestone and the following section was recorded.

25 m.	Pale grey, massive and thin bedded limestone with brachiopods as in the beds below and also *Horridonia geniculata* sp. nov., *Cancrinella* sp., *Laevicamera* sp., *Spirifer* sp., and *Dielasma* cf. *itaitubense* (DERBY).
13 m.	Massive grey, pink and red thin-bedded limestone with *Probolionia involuta* (TSCHERN.), *Waagenoconcha irginae* (STUCK.), *Chaoiella* cf. *grünewaldti* (KROT.), cf. *Anidanthus aagardi* (TOULA), *Chonetes* sp., and *Spiriferinae* gen. and sp. nov. ?
3 m.	Massive grey limestone with corals at the base.

Younger Dolomite (Hecla Hoek)

The outcrop of the Spirifer Limestone in the northern part of Bjørnøya is at least 20 m. thick, rests unconformably on the Ursa Sandstone, and has a thin basal conglomerate. The commonest brachiopods are *Waagenoconcha wimani* (FREDS.), *Costinifera arctica* (WHIT.), *Horridonia timanica* (STUCK.), and *Spirifer striatoparadoxus* TOULA. Of interest is the occurrence of *Craspedalosia pulchella* (DUNBAR), ? *Bathymyonia* sp., and *Pseudosyrinx wimani* sp. nov.

Correlation of the Carboniferous and Permian formations within Svalbard

The Carboniferous and Permian formations of Svalbard contain three distinct brachiopod faunas. The first of these occurs in the Campbellryggen Group, Scheteligfjellet Beds, Tårnkanten Sandstone, and Ambigua Limestone and confirms that these are broadly equivalent in age. These formations have been referred to the Middle Carboniferous by previous authors. The brachiopods they contain include species found in the upper Viséan of Great Britain and Belgium but persisting in younger rocks in the Moscow Basin. The fauna is probably closest to that of the Middle Carboniferous of the Moscow Basin where many of the species range from the upper half of C_1 into C_3. More precise dating of the Svalbard Middle Carboniferous is not possible at present.

The second brachiopod fauna occurs, in general, in the upper part of the Cyathophyllum Limestone. In particular, it characterizes the Upper Wordiekammen Limestone of Bünsow Land and the Cora Limestone of Bjørnøya. The Upper Wordiekammen Limestone has been referred to the Sakmarian (FORBES *et al.* 1958) and the brachiopod evidence supports this correlation.

The third, Brachiopod Chert, fauna has little in common with the Sakmarian but has a definite Upper Permian character as will be shown in section IV. The age of this fauna may be equivalent to that of the Mid-Permian unconformity widespread in the U.S.S.R. or to the Lower Kazanian. The brachiopods of the Brachiopod Cherty Limestone of Hornsund have Zechstein affinities; further discussion of this must await the work of CZARNIECKI.

The Lower Wordiekammen Limestone is known to belong to the *Triticites* zone (FORBES *et al.* 1958) and probably, in most areas, the lower part of the Cyathophyllum Limestone is of similar age. However, the brachiopod fauna of this part of the succession in sparse and poorly known.

The following table (Fig. 9) is a suggested correlation of the Carboniferous and Permian formations of Svalbard based mainly on brachiopod evidence.

III. SYSTEMATIC DESCRIPTIONS

Introduction

Sources of material

The following descriptions are based mainly on about 1300 specimens collected by expeditions from Cambridge and now deposited in the Sedgwick Museum. These were supplemented by about 300 undescribed specimens collected from Oscar II Land by the 1954 Birmingham Spitsbergen Expedition; about 150 specimens collected by various Norwegian expeditions, mainly under ISACHSEN and HOEL between 1907 and 1920, and in part described by HOLTEDAHL (1911) and FREBOLD (1937); about 30 undescribed specimens collected by WINSNES on the 1949 Norsk Polar Institutt Expedition; and about 100 specimens collected by the 1960 Durham Spitsbergen Expedition.

About 20 specimens collected by the Voyage de la Commission Scientifique du Nord in 1838, Mr. J. LAMONT in 1859 (mentioned by SALTER 1860), and Sir M. CONWAY's expedition in 1896–7 were lent to me by the British Museum. I have also been able to study some of the specimens described by TOULA (1874–5) which were lent by the Naturhistorisches Museum, Vienna. On a visit to Stockholm in 1960 I was able to examine the Swedish collections described by WIMAN (1914), the most important of which are those from Angelinberget, Nordaustlandet, collected on Nordenskiöld's 1868 expedition and those from Bjørnøya collected by ANDERSSON in 1899.

In the systematic descriptions the following abbreviations for repositories and sources are used: B. M. British Museum (Natural History), London; D. Durham Spitsbergen Expedition (1960); P. M. O. Palaeontological Museum, Oslo; R. M. S. Riksmuseum, Stockholm; S. M. Sedgwick Museum, Cambridge; X601–694 Birmingham Spitsbergen Expedition (1954), collection at the Department of Geology, Birmingham University.

Preservation

The majority of the brachiopods are preserved undistorted as recrystallized shells. Specimens occurring in shales or impure, thin-bedded limestones are frequently crushed; those in the more massive limestones are well-preserved in calcite but are sometimes difficult to extract from the matrix. The preservation of shells in the Spirifer Limestone is curiously varied. Lenses of impure limestone contain numerous brachiopods preserved in calcite or partly silicified. These shells lie in their original position, the long spines of the productids unbroken and supporting the shell lying on its pedicle valve with the brachial valve in place.

Numerous examples of one species are crowded together to the exclusion of other species. Some lenses consist almost entirely of *Costinifera arctica* (WHITFIELD), others of *Yakovlevia impressa* (TOULA) or *Spirifer-striato-paradoxus* (TOULA). The rock surrounding these lenses, and forming the bulk of the Spirifer Limestone, is frequently more siliceous and contains well-silicified, isolated valves with the spines broken off, and the surface worn and riddled with the burrows of soft-bodied boring animals. These disorientated and silicified valves are most commonly the heavy, thickened pedicle valves of *Spiriferella* species, *Cleiothyridina royssiana* (KEYS.) and *Streptorhynchus* species. The thin brachial valves are found in much fewer numbers and usually in a fragmentary condition.

This variation in preservation suggests that the silicification took place while the valves lay on the sea floor, in areas where slow deposition was effected by local current scour. Nearby shells could have been rapidly buried *in situ* on banks temporarily undisturbed by current action; some of these banks may have escaped later disturbance.

In the Brachiopod Chert, fossils are concentrated in beds or lenses separated by much thicker unfossiliferous chert beds. The brachiopods are sometimes silicified but often preserved as internal and external moulds. In shales within the Brachiopod Chert, the brachiopods are frequently formed of calcite and thin valves are crushed, e. g., those of *Cleiothyridina kotlukovi* STEPANOV and the anterior parts of *Paeckelmannella* aff. *expansa* (TSCHERN.).

Terminology

The descriptions of brachiopods that follow have been condensed into note form. The terminology follows, in the main, that used by COOPER (1944), MOORE (1952), and most other text books and general works. The terminology of the form of the anterior commissure is after BUCKMAN (1918, p. 83), and that of the position of the interarea after SCHUCHERT and COOPER (1932, p. 20). Special terms applying to the Productoidea are after MUIR-WOOD and COOPER (1960, p. 3–8). However, some terms are used in a more restricted or a special sense and these are listed below.

Border: a zone bordering the valve.

Margin: a line bordering the valve. The anterior and lateral margins are identical with the anterior and lateral commissures.

Costae: radial ridges on the exterior of the valves numbering less than 25 in 10 mm and formed of folds in the primary shell layer but obscured internally by the secondary shell layer. Costae include the costellae of MUIR-WOOD and COOPER (1960).

Capillae: as costae but numbering more than 25 in 10 mm and frequently superimposed on costae.

Plicae: radial ridges on the exterior of the valves formed of folds in the primary and secondary shell layers and thus visible on internal moulds.

Lirae: fine raised lines, not normally obvious without a lens, due to halts in growth of the shell.

Dental plates: simple shelly plates joining the sides of the delthyrium to the floor of the pedicle valve.

Dental lamellae: thickenings on the sides of the delthyrium which may be joined to the floor of the pedicle valve by adminiculae (q. v.).

Adminiculae: (see BROWN 1953, p. 102, and CAMPBELL 1959, p. 336) shelly plates arising from the floor of the pedicle valve and sometimes also in the brachial valve, converging slightly and frequently uniting with the dental lamellae with which they are not co-planar.

Classification

The classification of the Brachiopoda is under review by several authorities for the forthcoming brachiopod part of the "Treatise on Invertebrate Paleontology" (Ed. R. C. MOORE, University of Kansas Press). The most recent general classification is that given by MUIR-WOOD (1955), and this has been followed except for the Productoidea. This sub-order has been fully revised by MUIR-WOOD and COOPER (1960) and the classification used by these authors has been adopted.

Systematic descriptions of the brachiopods

List of descriptions

Descriptions

Class INARTICULATA HUXLEY, 1869
Order ATREMATA BEECHER, 1891
Superfamily Lingulacea WAAGEN, 1885
Family Lingulidæ, GRAY, 1840

Genus *Lingula* BRUGUIÈRE, 1792

1932 *Lingula* DUNBAR and CONDRA, p. 31

Genotype: *Patella unguis* Linneus

Lingula freboldi sp. nov.
Plate 1, figs. 1–2

Cf. 1936 *Lingula arctica* MILORADOVICH, (not WITTENBERG, 1910), p. 69, pl. 2, fig. 4, pl. 3, figs. 1–3.

?1960 *Lingula* cf. *arctica* HARKER, p. 49, pl. 15, fig. 12.

Type data

Holotype: S. M. E 18091
Paratypes: S. M. E 18092 – E 18101
Type locality: Högskulefjellet, South Dickson Land.

Description

Valves similar, moderately convex with flattened lateral and anterior borders. Outline sub-rectangular, rounded anteriorly and obtusely angular posteriorly; umbonal angle 120°. Lateral margins diverge slightly and greatest width is near anterior border.

The largest valves are 25 mm long. Most specimens are partly exfoliated and show the laminar structure of the shell. The external surface is marked by fine growth lines. No muscle impressions are visible but several valves show a narrow posterior median area, marked by fine longitudinal lines. On either side of this area are curved bands of light-coloured shell, convex posteriorly. I am unable to see whether these bands represent the ridges present in the pedicle valve of *L. arctica* MILORADOVICH (1936, pl. 2, fig. 4).

Discussion

This species is named in honour of Dr. H. FREBOLD. In size and external form the specimens resemble *L. arctica* MILORADOVICH. However, the internal characters are not preserved and cannot be compared with those described in detail by MILORADOVICH. *L. arctica* WITTENBERG (1910, p. 37, pl. 1, fig. 7) is a smaller species with a length of about 13 mm and an oval outline. It was collected from Triassic black shales at "Lamont Bucht" which probably lies on the north-west side of Ginevrabotnen.

L. polaris LUNDGREN resembles the present species in size but has a more rounded outline. It is a Triassic species described from Tschermakfjellet, Nordfjorden (LUNDGREN 1883, p. 20, pl. 2, fig. 14) and the Carnian of Urd, Miseryfjellet, Bjørnøya (BOEHM, 1903, p. 9, pl. 1, figs. 7–9).

Occurrence

Lingula freboldi sp. nov. was collected from the Upper Brachiopod Chert at Högskulefjellet (S. M. E 18091 – E 18101), Rundodden (S. M. E 18281), and Studentdalen (S. M. E 18276–9) on the north shore of Sassenfjorden; and from the Brachiopod Chert, station G 860, Oslobreen (S. M. E 18168). Some *Lingula* fragments (P. M. O. A 28323–4), collected from the Brachiopod Chert at Reinodden, Bellsund may belong to this species.

Lingula arctica MILORADOVICH was described from the Lower Permian of Mezhdusharsky Island, on the south-west coast of the South Island of Novaya Zemlya.

HARKER described specimens from the Assistance Formation of the Grinnell Peninsula, Devon Island, which may be conspecific with the Spitsbergen ones.

Lingula sp.
Plate 1, fig. 3

A fragment of dark limestone from south of Kapp Scott, Billefjorden and probably from the Lower Gypsiferous Series, contains several small exfoliated valves of *Lingula* (S. M. E 17895–901). These are about 5 mm long and oval in outline. They resemble DAVIDSON's figured specimens of *Lingula credneri* GEINITZ (DAVIDSON 1863, pl. 48, figs. 38–40). *L. mytiloides* SOWERBY is a larger species and *L. elliptica* PHILLIPS is more elongated.

Order NEOTREMATA BEECHER, 1891
Superfamily Discinacea WAAGEN, 1885
Family Discinidae GRAY, 1840
Subfamily Orbiculoideinae SCHUCHERT and LEVENE, 1929

Genus *Orbiculoidea* D'ORBIGNY, 1847

1932 *Orbiculoidea* DUNBAR and CONDRA, p. 41

Genotype: *Orbicula forbesi* DAVIDSON

Orbiculoidea winsnesi sp. nov.
Plate 1, figs. 4–5

?1960 *Orbiculoidea* sp. HARKER, p. 49, pl. 15, Figs. 10–11.

Type data

Holotype: P. M. O. A 26271.
Paratypes: P. M. O. A 26270, A 26272, A 26415.
Type locality: Skarvrypehøgda, Sassendalen, Spitsbergen.

Description

Large *Orbiculoidea* with resupinate pedicle valve, concave anterior to apex, sub-circular in outline, length slightly greater than width. Pedicle opening elongate oval, extending posteriorly from apex. Sculpture of fine concentric ridges which probably represent growth lamellae. Internal characters unknown.

A brachial valve tentatively referred to this species has the apex about a third of the diameter from the anterior margin and a similar sculpture to that of the pedicle valve.

Discussion

This species is named in honour of Mr. T. S. WINSNES of Norsk Polarinstitutt.

Orbiculoidea winsnesi sp. nov. resembles *O. capuliformis* (MCCHESNEY) as figured by DUNBAR and CONDRA (1932, pl. 1, figs. 20–22). However, MCCHESNEY in his description of this Pennsylvanian species (quoted from DUNBAR and CONDRA, p. 47) wrote "Smaller valve rather deeply concave, ... with a linear sulcus extending from the center of the depression to the border of the valve on the

short side:". The anterior part of the pedicle valve of *Orbiculoidea winsnesi* sp. nov. is gently convex and bears no sulcus.

Orbiculoidea sp. HARKER (1960) from the Assistance Formation, Grinnell Peninsula differs from *Orbiculoidea winsnesi* sp. nov. only in its more circular outline; the two forms are probably conspecific.

Occurrence

Apart from the type specimens, one brachial valve (S. M. E 18280) possibly belongs to this species. It is from the Upper Brachiopod Chert of Studentdalen, north shore of Billefjorden. This specimen was associated with *Lingula freboldi* sp. nov.

Orbiculoidea sp.
Plate 1, fig. 6

Two pedicle valves. One (S. M. E 17902) is sub-circular with a diameter of 10 mm. It is associated with *Lingula* sp. from ?Lower Gypsiferous Series, south of Kapp Scott, Billefjorden. The other (S. M. E 18302) is a circular valve with a diameter of 17 mm and has an oval pedicle opening extending 3.5 mm anterior to the centre of the valve. The interior of the valve is exposed and shows fine radial grooves. It was collected from the scree *ex* Wordiekammen Limestone, on Teltfjellet, Bünsow Land.

Class ARTICULATA HUXLEY, 1869
Suborder DALMANELLOIDEA MOORE, 1952
Superfamily Dalmanellacea SCHUCHERT and COOPER, 1931
Family Rhipidomellidae SCHUCHERT, 1913, emend SCHUCHERT and COOPER, 1932.

Genus *Rhipidomella* OEHLERT, 1890
Genotype: *Terebratula michelini* L'ÉVEILLÉ

Rhipidomella michelini (L'ÉVEILLÉ)
Plate 1, fig. 7

1835 *Terebratula michelini* L'ÉVEILLÉ, p. 39, pl. 2, figs. 14–17.
1909 *Rhipidomella michelini* LEE, p. 166, pl. 1, fig. 16.
1911 *Rhipidomella michelini* HOLTEDAHL, p. 25, pl. 5, figs. 1–2.
1934 *Rhipidomella michelini* DEMANET, p. 37, pl. 2, figs. 1–9.
1939 *Rhipidomella michelini* LICHAREW and EINOR, p. 12, pl. 1, figs. 1 a–c, 4 a–b.
1952 *Rhipidomella michelini* SARYCHEVA and SOKOLSKAYA, p. 22, pl. 1, No. 7.

Description

Outline rounded-triangular with greatest width (20–25 mm) in the anterior half of the valves. Hinge line about a third the width. Pedicle valve flattened and slightly resupinate. Interarea low, with open delthyrium; umbo pointed. Brachial valve slightly convex with low interarea and notothyrium covered by convex chilidium. The original substance of the valves has been replaced by silica of

coarse texture, but a sculpture of fine costae, about 16 in 5 mm, crossed by growth lines, is clearly visible in one specimen. Interior of valves not seen.

Discussion

In external characters the specimens agree closely with the Belgian Tournaisian species *R. michelini* as figured by L'ÉVEILLÉ and by DEMANET. L'ÉVEILLÉ figured a shell in lateral aspect showing the anterior border of both valves thickened and costate. This character is not present in the specimens from Spitsbergen and is not shown in DEMANET's clear figures.

Rhipidomella michelini differs from *R. burlingtonensis* HALL in having a shorter hinge line and less pointed umbo. *R. pecosi* MARCOU is smaller, has a more rounded outline and is more convex. *R. pennana* (DERBY) has a similar shape but is characterized by its very thick valves.

Occurrence

R. michelini was first recorded from the arctic by LEE (1909) who described specimens from the Lower Carboniferous of Cape Cherny, South Island of Novaya Zemlya. LICHAREW and EINOR (1939) recorded two specimens from Russian Harbour in the North Island. In Spitsbergen it was described from the Scheteligfjellet Beds, Brøggerhalvøya (HOLTEDAHL 1911). The specimens described here are from the Tårnkanten Sandstone of Jutulslottet (X 622(4)), Robertsonfjellet (S. M. E 18841) and an unknown locality (X 606), Oscar II Land.

In north-west Europe *R. michelini* has an extensive range in the Lower Carboniferous. In the Moscow Basin it occurs in the upper part of the Lower Carboniferous (C_1^{tl}, C_1^{tr}, C_1^{st}) and less commonly in the Moscovian (C_2^{pd}, C_2^{m}) and Gzelian (C_3^{gj}) (SARYCHEVA and SOKOLSKAYA, 1952).

Family Schizophoriidae SCHUCHERT and LEVENE, 1929
Subfamily Schizophoriinae SCHUCHERT and LEVENE, 1929

Genus *Orthotichia* HALL and CLARKE, 1892
Genotype: *Orthis? morganiana* DERBY

Orthotichia cf. *morganiana* (DERBY, 1874)
Plate 1, figs. 8–10

1911 *Orthotichia morgani* HOLTEDAHL, p. 28, pl. 4, fig. 8, pl. 5, figs. 4–7.

Description

Valves wider than long, suboval in outline. Hinge line does not exceed half the width. Shell thin and distorted in the majority of specimens. Pedicle valve flattened resupinate with broad, ill-defined sulcus. Brachial valve larger, convex, but flattening anteriorly. Interareas obscure. Sculpture of fine capillae, 25 in 5 mm, on both valves, superimposed on regular costae, about three in 5 mm which are more numerous and more prominent at the flattened anterior margin. Median septum and dental plates visible through worn shell of pedicle valve.

One specimen (S. M. E 18125) was ground on the pedicle valve to reveal these structures more clearly and establish the generic designation.

Discussion

The specimens are all partly crushed. The pedicle valve is flatter than that of *O. morganiana* figured by DERBY (1874, p. 29, pl. 3, figs. 1–7, 9, 11, 34, pl. 4, figs. 6, 14, 15) and KATZER (1903, p. 164, pl. 5, figs. 6a–f). This may be due to distortion which, according to DERBY, commonly occurs. The specimens described by TSCHERNYSCHEW (1902, p. 594, pl. 26, figs. 8–10, pl. 48, figs. 1–3) as *O. morganiana* are also more inflated and the anterior commissure more strongly plicated. LICHAREW and EINOR (1939, p. 13, pl. 1, figs. 3–5) described *O. morganiana* from Novaya Zemlya but their figures are too poor to be used for comparison. FREBOLD (1950, p. 40, pl. 6, figs. 5, 5a) figured a small brachial valve from the Upper Carboniferous of Holm Land, north-east Greenland. This specimen does not appear conspecific with the Spitsbergen forms.

Occurrence

HOLTEDAHL (1911) described this species from the Scheteligfjellet Beds, Brøggerhalvøya. The present specimens are from the base of the Passage Beds, Sfinksen, Billefjorden (S. M. E 18125–8), and from the Tårnkanten Sandstone, Robertsonfjellet (X 633), locality unknown (X 610).

O. morganiana (DERBY) was originally described from the Itaituba Series (Middle Pennsylvanian) of Brazil.

Suborder STROPHOMENOIDEA MAILLIEUX, 1932,
emend. ÖPIK, 1934, emend. WILLIAMS, 1953.
Superfamily Orthotetacea WILLIAMS, 1953, emend.
STEHLI, 1954.
Family Schuchertellidae STEHLI, 1954
Subfamily Schuchertellinae STEHLI, 1954

Genus *Schuchertella* GIRTY, 1904
Genotype: *Streptorhynchus lens* WHITE

Schuchertella cf. *rovnensis* YANISCHEWSKY
Plate 1, figs. 11–13

Cf. 1952 *Schuchertella rovnensis* SARYCHEVA and SOKOLSKAYA, p. 43, pl. 4, No. 28.

Description

Large *Schuchertella* up to 50 mm in width. Outline semicircular with hinge line equal to or slightly less than greatest width. Pedicle valve has a cone-like umbo and flat anterior and lateral areas; low interarea bears convex deltidium covering broad delthyrium. Delthyrial angle 90°. Brachial valve gently and regularly convex; interarea not seen. Sculpture of fine costae, 16 in 10 mm, increasing

by intercalation and crossed by fine, scalloped growth lines. Intercostal sulci about four times as broad as costae. Interior of pedicle valve without dental plates or median septum.

Discussion

The majority of the specimens are pedicle valves showing the external surface only. They do not form an adequate basis for a new species and are best compared with the Russian *S. rovnensis*. They differ from this species, as figured by SARYCHEVA, in having more numerous costae; which, however, are not as numerous as those of *S. wexfordensis* SMYTH.

Occurrence

Abundant locally in argillaceous limestones in the Tårnkanten Sandstone, Robertsonfjellet (X 637(3), X 638), unknown locality (X 611, S. M. E 18828–30, X 613(4)). *S. rovnensis* occurs abundantly in the upper part of the Viséan (C_1^{tr}) in the north-west of the Moscow basin.

Schuchertella sp.

Two specimens (S. M. E 17911–2) collected from scree, probably derived from the Passage Beds of Ebbadalen, differ from *S. rovnensis* in having more numerous and finer costae. They probably belong to a distinct species.

Subfamily Streptorhynchinae STEHLI, 1954, emend. THOMAS, 1958

Genus *Streptorhynchus* KING, 1850

Genotype: *Terebratulites pelargonatus* SCHLOTHEIM

Streptorhynchus macrocardinalis TOULA

Plate 2, figs. 4–5

1875 c *Streptorhynchus crenistria* var. *macrocardinalis* TOULA, p. 253, pl. 8, figs. 5 a–b.
1914 *Streptorhynchus macrocardinalis* WIMAN, p. 56, pl. 9, figs. 1–23, pl. 10, figs. 20–21.
1937 a *Streptorhynchus macrocardinalis* STEPANOV, p. 109, pl. 1, figs. 1 a–b.
1958 *Streptorhynchus macrocardinalis* FORBES, p. 475.

Type data

Lectotype (here selected): the specimen figured by TOULA, 1875 c, pl. 8, fig. 5 a. This is an internal mould of a pedicle valve.

Type locality: North of Kapp Wærn, Spitsbergen, probably Spirifer Limestone or its equivalent.

Description

WIMAN figured this species adequately, but his description was not very complete. A full description is therefore given here. Forty-two specimens are in the Sedgwick Museum, all isolated valves of which only three (S. M. E 17630, E

18640–1) are adult brachial valves. They are well preserved; many were silicified and have been etched from the matrix with acid.

Pedical valve sub-circular in outline, almost flat, very thick; umbo pointed. Sculpture of high costae which have rounded crests, radiate from the umbo, increase by intercalation and number 20–22 in 10 mm.

The palintrope, in young specimens, is formed only of the triangular interarea. During growth, the posterolateral margins of the pedicle valve are added to form a broad, relatively low palintrope in the adult. This later addition is sculptured in the same way as the main part of the valve. The apical angle of the interarea remains constant at 100°, but that of the palintrope increases to 130° or more. The perideltidium is not visible. (This is stated by DUNBAR and CONDRA, 1932, p. 68, to be invariably present in orthotetids, but not always visible unless the preservation is perfect.)

Narrow delthyrium with an apical angle of about 30° covered by deltidium with narrow, convex central zone bordered by flattened areas. Interior of pedical valve with thickened lateral chambers. Dental plates do not extend to prominent peg-like teeth. Muscle impressions central, circular in outline, and deeply impressed in adult specimens. Adductor impressions narrow and separated by a low ridge but median septum absent. Diductor impressions broad, marked with radiating ridges.

In large shells the umbo is thickened and the lateral and anterior borders of the muscle impressions are also thickened into a broad ridge, sloping down to the lateral and anterior margins. The latero-anterior border is recurved over the inside of the valve and a deep groove is developed, into which fits the edge of the brachial valve.

Brachial valve convex, circular in outline and sculptured similarly to the pedical valve. Interarea minute, and poorly preserved. Interior with broad median swelling but no median septum. Adductor muscle impressions large and divided by radial ridges. Cardinal process of normal orthotetid type, flattened transversely quadrifid, and supported by divergent socket plates, not recurved (see THOMAS 1958, p. 9).

Margins of both valves thin and finely pectinate.

Discussion

WIMAN examined TOULA's original specimens and confirmed that his material belonged to TOULA's species. According to WIMAN, TOULA figured his specimens inaccurately. He observed that the hinge-line (i. e. the anterior margin of the palintrope) was drawn too straight, the elevated ridges in the middle of the muscle field and a septum shown in TOULA's figure were not present on the original, and the brachial valve was more convex than it was represented.

Occurrence

This species is known only from the Spirifer Limestone of Spitsbergen, in which it is often abundant. TOULA recorded it from "the land between the two arms of Nordfjorden", i. e. north of Kapp Wærn. WIMAN noted it

from Kapp Wijk, Bjonahamna, and Flowerdalen, and STEPANOV from Tempelfjorden. The specimens described here are from Tempelfjorden, cliff west of Kapp Schoultz (S. M. E 18215–7), Gerardfjella (S. M. E 18365–70), Bjonahamna (S. M. E 18629–41); Bünsow Land, Tyrellfjellet, (S. M. E 17629–38), Skansbukta (S. M. E 18424–32), and Oscar II Land, Heimberget (X 673).

Streptorhynchus kempei WIMAN
Plate 2, fig. 3

1914 *Streptorhynchus kempei* WIMAN, p. 58, pl. 10, figs. 22–27, pl. 11, figs. 1–10, pl. 12, figs. 1–8, pl. 13, figs. 11–13.
1931 *Streptorhynchus kempei* FREBOLD, p. 19, 29, 41, pl. 6, figs. 1–3.
1937 a *Streptorhynchus kempei* STEPANOV, p. 109, pl. 1, figs. 2, 6.
1955 *Streptorhynchus kempei* DUNBAR, p. 63, pl. 1, figs. 1–13, pl. 32, figs. 9–10.
1958 *Streptorhynchus kempei* FORBES, p. 475.
1960 *Streptorhynchus kempei* HARKER, p. 50, pl. 15, figs. 1–6.

Type data

Lectotype (here selected); the specimen figured by WIMAN, 1914, pl. 10 figs. 24–27.

Type locality: Spirifer Limestone, Alfredfjellet, Bjørnøya.

Discussion

As this species has been fully described by DUNBAR (1955, p. 63), it is not redescribed here. DUNBAR noted the variability of the shell and thought that the identity of the Greenland specimens needed confirmation. He remarked that the exterior of the valves were poorly figured by WIMAN, who described the sculpture as of fine angular costae, 13 in 10 mm. In the Greenland specimens 20 costae occupied a space of 10 mm.

The Svalbard specimens I have seen, agree closely with DUNBAR's figures. The growth varices are less marked but the costae number 20 in 10 mm (this also appears to be the case on WIMAN's figured specimens). The variation in form of the pedicle valve and in the inclination and shape of the pedicle interarea was noted and figured by WIMAN.

S. kempei differs from *S. macrocardinalis* in having a thicker, less flattened, more cone-like pedicle valve with a palintrope consisting of the interarea only. The umbo is often twisted.

Occurrence

S. kempei is found in Svalbard in the Lower and Middle Brachiopod Chert, occurring most abundantly in the Spirifer Limestone. WIMAN records it from Alfredfjellet and Miseryfjellet on Bjørnøya; from Flowerdalen, Lovénberget, Stenbrohultdalen, Skansbukta and Kapp Wijk, in Spitsbergen.

The present specimens are from the Spirifer Limestone of Bjørnøya, Miseryfjellet (S. M. E 17943), north side of Lakselva (S. M. E 17930); Spirifer Limestone of Spitsbergen, Oslobreen (S. M. E 18157), Bjonahamna (S. M. E 18519,

E 18618–9), Gipshuken (S. M. E 17537–8, E 18774–80), Tyrellfjellet (S. M. E 17610, E 18691); ?Lower Brachiopod Chert, Högbomfjellet (P. M. O. A 26318); Middle Brachiopod Chert, Templet (S. M. E 17474, E 17484, E 17486–7).

This species is widespread in the Permian of east Greenland (see DUNBAR, 1955, p. 65). A single specimen from Kap Jungersen, Amdrups Land, north-east Greenland, was compared with *S. kempei* by FREBOLD (1950, p. 42, pl. 1, figs. 4, 4 a). HARKER (1960) described *S. kempei* from the Assistance Formation, Grinnell Peninsula, Devon Island. It was also recorded from the Pai Choi mountains, U. S. S. R. by SOLOMINA (1960).

Streptorhynchus triangularis WIMAN
Plate 1, figs. 14–15

1914 *Streptorhynchus triangularis* WIMAN, p. 55, pl. 10, figs. 1–19, 28–29.
1937 a *Streptorhynchus triangularis* STEPANOV, p. 109, pl. 1, fig. 3.
1958 *Streptorhynchus triangularis* FORBES, p. 475.
1960 *Streptorhynchus triangularis* HARKER, p. 51, pl. 15, figs. 7–9.

Type data

Lectotype (here selected): the specimen figured by WIMAN, 1914, pl. 10, figs. 18–19.

Type locality: Spirifer Limestone, Stenbrohultdalen, Grönfjorden, Spitsbergen.

Discussion

This species was described by WIMAN. It differs from *S. macrocardinalis* in its smaller size and triangular outline, the greatest width lying in the anterior part of the shell. Young *S. macrocardinalis* are sub-circular in outline. In adult specimens of *triangularis,* as in *macrocardinalis,* the postero-lateral borders of the pedicle valve grow dorsally to form part of the palintrope. However most of the palintrope is formed by the interarea and remains triangular in outline. As WIMAN pointed out, the posterior margin of the palintrope and the lateral commissure meet at an angle and do not form a continuous curve as in *macrocardinalis*. The costae on the exterior of the pedicle valve number 25 in 10 mm.

The specimens in the Sedgwick Museum are pedicle valves but most are silicified and have been etched from the matrix with acid. They differ from *S. pelargonatus* (SCHLOTHEIM) and *S. stoschensis* DUNBAR, in the flatter pedical valve and less produced, more regular umbo.

Occurrence

S. triangularis occurs in the Spirifer Limestone of Spitsbergen, where it is less common than the two *Streptorhynchus* spp. described above. WIMAN and STEPANOV note it only from Stenbrohultdalen. The present material is from Bjonahamna (S. M. E 18861), Gipshuken (S. M. E 17588), and Tyrellfjellet (S. M. E 17639) in Bünsow Land, and from Skivefjellet (X 643) and Heimberget (S. M E 18850–1, X 677(5)), in Oscar II Land.

The only other record of *S. triangularis* is from the Assistance Formation, Grinnell Peninsula, Devon Island (HARKER 1960).

Streptorhynchus sp.

1911 *Streptorhynchus pelagonatus* HOLTEDAHL (not SCHLOTHEIM), p. 24, pl. 4, fig. 6.

HOLTEDAHL's specimen (P. M. O. A 4080) is a pedicle valve of a small *Streptorhynchus* with a sub-circular outline broken by the pointed but undistorted umbo (umbonal angle 90°). The hinge line equals two thirds of the greatest width. The broadly triangular interarea has a relatively broad delthyrium (delthyrial angle 50°) covered by a convex deltidium.

This shell was collected from the Scheteligfjellet Beds, Brøggerhalvøya. It differs from the Moscovian *S. mjatschowensis* SOKOLSKAYA in the flatter pedicle valve and lower interarea.

Subfamily Derbyiinae STEHLI, 1954

Genus *Derbyia* WAAGEN, 1884

Genotype: *Derbyia regularis* WAAGEN

Derbyia aff. *grandis* WAAGEN, 1884

Plate 2, figs. 1–2

?1902 *Derbyia grandis* TSCHERNYSCHEW, (not WAAGEN), p. 580, pl. 24, figs. 1–2, pl. 26, fig. 5.
?1916 *Derbyia grandis* TSCHERNYSCHEW and STEPANOV, (not WAAGEN), p. 67, pl. 10, figs. 1 a-b.
1937 a *Derbyia* cf. *grandis* STEPANOV, p. 110, pl. 1, fig. 5.
?1950 *Derbyia grandis* FREBOLD, (not WAAGEN), pl. 1, figs. 5,5 a.
1960 *Derbyia* cf. *grandis* HARKER, p. 52, pl. 16, figs. 9–10.

Description

Large *Derbyia* up to 90 mm in length and 100 mm or more in width. Shell outline rounded, hinge line equal to or slightly less than greatest width. Pedicle valve flattened, irregular, slightly resupinate. Pedicle interarea large (24 mm high), flat, apsacline, triangular in outline. Delthyrium covered by regularly convex deltidium, having shallow posterior median groove and concave anterior border. Delthyrial angle about 35°. Perideltidium slightly raised and marked with vertical lirae; perideltidial angle about 100°. Brachial valve gently convex with broad, shallow, median sulcus. Irregular costae, numbering about 14 in 10 mm and irregular growth varices on both valves.

Interior of pedicle valve with prominent peg-like teeth and thick, low, dental lamellae. Thin median septum divides muscle impressions, posterior border of which coincide with resupination of valve. Brachial valve interior with broad median platform.

There is only one brachial valve among the specimens and the posterior part of that is missing. The median septum of the pedicle valve (S. M. E 18522) is 10 mm high in the centre but, possibly due to damage, rapidly diminishes in height posteriorly and anteriorly.

Discussion

Shells of this type from the arctic, have usually been identified or compared with *Derbyia grandis* WAAGEN. The latter specimen differs from the present specimens in possessing a more convex pedicle valve with a less regular interarea and a narrower deltidial plate. *D. regularis* WAAGEN is smaller and also has a more convex pedicle valve.

TSCHERNYSCHEW does not figure a complete area or a specimen in lateral aspect and he says nothing about the convexity of the valves. It is probable that one or more species of large *Derbyia* are present in the arctic fauna. Their size renders them difficult to collect whole and the Spitsbergen material has so far been inadequate on which to base a new species. However, the specimen from the Assistance Formation, described by HARKER (1960) is complete, and may be closely compared with the present specimens, particularly with regard to its irregularly flattened pedicle valve.

TOULA (1874, p. 274, pl. 3, figs. a–b) described a *Derbyia* sp. as *Streptorhynchus crenistria*. His specimen is smaller than those described above, having a width of 86 mm, a hinge line of 80 mm, and a length of 66 mm. The costae are coarser, more regular, and number nine in 10 mm; and the deltidium forms an equiangular triangle. It resembles *D. arizonensis* MCKEE and may be conspecific with a species from east Greenland, described by DUNBAR (1955, p. 66, pl. 2, figs. 16–20) as *Derbyia* sp. A.

Occurrence

Only three specimens in the Sedgwick Museum certainly belong to *D.* aff. *grandis* WAAGEN. These are from the Spirifer Limestone of Bjonahamna, Tempelfjorden (S. M. E 18520–2). STEPANOV describes a specimen from the Cyathophyllum Limestone of Tempelfjorden.

The following specimens are fragmentary pedical valves of *Derbyia* sp.: Spirifer Limestone, north side of Lakselva, Bjørnøya (S. M. E 17928); Scree, station W 139, Oslobreen (S. M. E 18868); Spirifer Limestone, Bjonahamna (S. M. E 18519); Upper Cyathophyllum Limestone, Gipsvika (S. M. E 17372).

Family Orthotetidae WAAGEN, 1884, emend. STEHLI, 1954
Subfamily Meekellinae STEHLI, 1954

Genus *Meekella* WHITE and ST. JOHN, 1867

Genotype: *Plicatula striatocostata* COX

Meekella cf. *timanica* TSCHERNYSCHEW
Plate 1, figs. 16–17

Cf. 1902 *Meekella timanica* TSCHERNYSCHEW, p. 525, pl. 25, figs. 4 a–c.

Description

This species is represented by a single specimen showing the exterior of the pedicle valve and a small area of the brachial valve.

Large *Meekella*, 45 mm in width. Outline subcircular, hinge line less than greatest width. Pedicle valve slightly and irregularly convex, with 13 rounded, irregular plicae on which are superimposed capillae, numbering 30–35 in 10 mm, and increasing in number by intercalation. Interarea high, triangular in outline, with narrow delthyrium covered by convex deltidium; delthyrial angle about 20°. Perideltidium marked by vertical lirae: perideltidial angle about 80°.

The umbo is broken off and the narrow dental plates are seen to converge slightly anteriorly. The brachial valve appears to be convex.

Discussion

This specimen has the form of *M. timanica* but is smaller and has larger plicae. *M. eximia* (EICHWALD) is smaller and has a more convex pedicle valve. *M. kueichowensis* HUANG has sharper and more numerous plicae.

The specimens described as *M. eximia* by HOLTEDAHL (1911, p. 25, pl. 4, fig. 9) and STEPANOV (1937, p. 111, pl. 1, fig. 7) may be conspecific with the present specimen.

Occurrence

Scree, station W 139, Oslobreen (S. M. E 18413). Carboniferous and possibly Permian strata are exposed on station W 139, although it is doubtful whether the Spirifer Limestone horizon is present.

The *Meekella* described by HOLTEDAHL and STEPANOV were probably from the Cyathophyllum Limestone.

Suborder PRODUCTOIDEA MAILLIEUX, 1940, emend.
MUIR-WOOD and COOPER, 1960
Superfamily Strophalosiacea MUIR-WOOD and COOPER, 1960
Family Strophalosiidae SCHUCHERT, 1913
Subfamily Heteralosiinae MUIR-WOOD and COOPER, 1960

Genus *Craspedalosia* MUIR-WOOD and COOPER, 1960, p. 82
Genotype: *Orthothyrix lamellosa* GEINITZ

Craspedalosia pulchella (DUNBAR)
Plate 2, figs. 6–10

1875 a *Strophalosia* sp. TOULA, p. 276, pl. 2, figs. 5 a–b.
1937 *Strophalosia* (*Aulosteges?*) sp. indet. FREBOLD, p. 42, pl. 3, figs. 4–7, pl. 8, fig. 3.
1955 *Strophalosia pulchella* DUNBAR, p. 81, pl. 7, figs. 11–22.

Discussion

Strophalosia pulchella DUNBAR was included by MUIR-WOOD and COOPER (1960) in *Craspedalosia*. It differs from the genotype in its triangular outline, shorter hinge, and in the form of the cardinal process which is raised on a narrow shaft above the plane of the brachial valve. In these characters, and also in the extensive

muscle impressions of the pedicle valve, it resembles *Sphenalosia* MUIR-WOOD and COOPER (1960, p. 87), which however has a bilobed cardinal process.

The Spitsbergen specimens are not so well preserved at the best of DUNBAR's specimens but they agree in all respects with his description and are not re-described here. Two silicified brachial valves show the narrow, erect cardinal process and the form of the adductor muscle impressions.

Occurrence

Spirifer Limestone, Spitsbergen, Pyramiden summit (P. M. O. A 4950); Bjørnøya, east bay of Herwighamna (S. M. E 17914), west point of Lundenæringane (S. M. E 17924–6), north side of Lakselva (S. M. E 17932–3). The specimens described by TOULA and FREBOLD were from Sørkappøya (P. M. O. A 9248, A 9733, A 9735, A 9737–9, A 9746, A 9750, A 9997, A 10000, A 10018, A 10020 –24, A 10026–28, A 10030–32).

Family Aulostegidae MUIR-WOOD and COOPER, 1960
Subfamily Aulosteginae MUIR-WOOD and COOPER, 1960

Genus *Aulosteges* VON HELMERSEN 1847, emend MUIR-WOOD and COOPER 1960, p. 95

Genotype: *Orthis wangenheimi* VERNEUIL.

Aulosteges sp.
Plate 2, figs. 11–12

Description

Outline broadly triangular with greatest width anteriorly. Pedicle valve convex with broad, flattened umbo and flattened flanks produced into poorly defined ears. Median sulcus broad and rounded. Interarea orthocline, broadly triangular with irregular sides. Narrow convex elytridium. Brachial valve poorly preserved, flat becoming concave anteriorly. Lophidium present. Pedicle valve covered with irregular spines about 0.5 mm in diameter, and marked with concentric growth lines. Sculpture of brachial valve uncertain but probably spinose.

Discussion

A single specimen (S. M. E 17323) from the Upper Wordiekammen Limestone of Tyrellfjellet. This resembles *A. dalhousi* DAVIDSON but that species has an apsacline interarea. A specimen from the Spirifer Limestone of Tempelfjorden, described as *Aulosteges grangeri* GRABAU by STEPANOV (1937, p. 138, pl. 5, fig. 12) has a sub-circular outline and a relatively larger interarea than the specimen described here and is probably specifically distinct.

Family Sinuatellidae MUIR-WOOD and COOPER, 1960

Genus *Sinuatella* MUIR-WOOD

1928 *Sinuatella* MUIR-WOOD, p. 37.
1960 *Sinuatella* MUIR-WOOD and COOPER, p. 125.

Genotype: *Leptaena sinuata* DE KONINCK.

Sinuatella sinuata (De Koninck)
Plate 2, figs. 13–18

1851 *Leptaena sinuata* De Koninck, p. 654, pl. 56, figs. 2 a–e.
1928 *Sinuatella sinuata* Muir-Wood, pl. 12, figs. 11–15.
1960 *Sinuatella sinuata* Muir-Wood and Cooper, pl. 57, figs. 1–14.

Description

Strongly geniculated shells, rectangular in outline. Hinge line (about 20 mm) equals greatest width. Pedicle valve visceral disc flattened and slightly raised above flat ears. Narrow median sulcus developed a few mm anterior to umbo, deepening anteriorly, and on trail dividing convex lateral humps. Umbo broad, not transgressing hinge line. Pedicle interarea low, smooth; delthyrium covered by convex deltidium. Brachial valve similar in form to pedicle valve and shell cavity narrow.

Both valves with narrow costae, beginning about 2 mm anterior to umbo and numbering about 10 in 5 mm on trail. Visceral disc crossed by about 15 concentric rugae forming small nodes where they cross the finer costae. Ears smooth. Spine bases small and their distribution obscure. The internal characters were not seen.

Discussion

The specimens were compared with British specimens of *S. sinuata* in the Sedgwick Museum, two of which were figured by Muir-Wood (1928, pl. 12, figs. 11–12, 15). Most of the British specimens have a flatter visceral disc with slightly more pronounced rugae. However, in all other characters they agree with the Spitsbergen specimens.

Occurrence

Five specimens (X 631, S. M. E 18839–40) from the Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land. One of these (X 631) is associated with a pedicle valve of *Echinoconchus elegans* (M'Coy).

In Britain *S. sinuata* occurs in the upper part of the Viséan.

Superfamily Productacea Waagen, 1883
Family Overtoniidae Muir-Wood and Cooper, 1960
Subfamily Overtoniinae Muir-Wood and Cooper, 1960

Genus *Krotovia* Fredericks, 1928, emend. Muir-Wood and Cooper, 1960

1928 *Krotovia* Fredericks, p. 779, 790.
1955 *Krotovia* Dunbar, p. 83.
1960 *Krotovia* Muir-Wood and Cooper, p. 188.

Genotype: *Productus spinulosus* J. Sowerby

Krotovia licharewi (FREBOLD)
Plate 3, figs. 1–10

1942 *Productus licharewi* FREBOLD, p. 38, pl. 3, figs. 7–9.
1955 *Krotovia nielseni* DUNBAR, p. 84, pl. 8, figs. 1–6.

Type data

Holotype: The specimen figured by FREBOLD, 1942, pl. 3, fig. 7, which is in the Mineralogical Museum, Copenhagen.

Type locality: Kap Stosch, east Greenland.

Description

Outline sub-circular. Pedicle valve evenly convex; sulcus absent. Umbo narrow, inflated, the tip sharply hooked and over-arching the hinge line. Ears relatively large, flattened, proximally clearly delineated from umbonal slopes but distally merging with lateral slopes. Brachial valve with evenly concave visceral area and flattened ears. Sculpture on both valves of uneven rows of small, erect spine bases, 8–10 in 4 sq. mm and very fine growth lines.

The internal characters were not seen.

Discussion

DUNBAR renamed this species having apparently overlooked FREBOLD's earlier description. The material studied by these two authors was collected from the neighbourhood of Kap Stosch, east Greenland, and there is little doubt that it represents but one species. The Spitsbergen specimens described here resemble more closely FREBOLD's figured specimens than those of DUNBAR which have relatively smaller ears and thus a more triangular outline.

Krotovia licharewi resembles *K. grabaui* (CHAO) in size and shape but the latter, which is Viséan, has extremely fine spine bases and a row of larger spines on the lateral slopes.

Occurrence

East Greenland: Productus Limestone, east of Kap Stosch. Martinia-Productus beds, Margrethedal, Clavering Ø.

Spitsbergen: Middle Brachiopod Chert, Gipshuken, Bünsow Land, (S. M. E 17727–31). Loose block, Gerardfjella, (S. M. E 18359).

Krotovia cf. *pustulata* (KEYSERLING, 1854)

One worn pedicle valve (P. M. O. A 4953), which resembles *K. pustulata* in form, was collected from the summit of Pyramiden, Billefjorden. *Productus pustulatus* HOLTEDAHL (1911, p. 33, pl. 2, fig. 4) is a *Krotovia* with fewer and larger spine bases than *K. pustulata* (KEYSERLING).

Krotovia cf. *wallacei* (TSCHERNYSCHEW, 1902)

1911 *Productus* cf. *wallacei* HOLTEDAHL, p. 31, pl. 5, fig. 14.
?1917 *Productus wallacianus* GRÖNWALL (not DERBY), p. 583, pl. 29, figs. 1–2 only.

HOLTEDAHL's specimen from the Scheteligfjellet Beds, is a worn pedicle valve (P. M. O. A 4177) which cannot be identified with certainty. Four specimens (S. M. E 18863–6) from the Passage Beds of Sfinksen, Billefjorden and one (S. M. E 18862) from the Ambigua Limestone, north of Kapp Kåre, Bjørnøya, are probably conspecific with HOLTEDAHL's specimen.

Family Margiferidae STEHLI, 1954
Subfamily Margiferinae STEHLI, 1954

Genus *Eomarginifera* MUIR-WOOD, 1930

1930 *Eomarginifera* MUIR-WOOD, p. 103.
1960 *Eomarginifera* MUIR-WOOD and COOPER, p. 209.
Genotype: *Productus longispinus* J. SOWERBY.

Eomarginifera longispina (J. SOWERBY, 1814)
Plate 3, figs. 11–20

1911 *Productus longispinus* HOLTEDAHL, p. 30, pl. 4, fig. 5.
1928 *Productus longispinus* MUIR-WOOD, p. 156, pl. 11, figs. 1–4.
?1950 *Productus longispinus* FREBOLD, p. 54, pl. 2, fig. 8.

Description

Small (width about 13 mm), quadrate in outline. Pedicle valve geniculate, with small, broad, but sharply pointed umbo. Geniculation crosses centre of visceral disc, dividing gently convex posterior and anterior areas. Ears small, slightly arched. Sulcus absent or weakly developed on the geniculation and anterior part of the visceral disc. Flanks steep. Trail broken off. Brachial valve geniculate, with concave visceral disc; anterior border thickened by overlapping lamellae, representing successive broken-off trails. Sculpture of regular capillae, 25–26 in 10 mm. About eight concentric rugae cross posterior part of pedicle valve. Six halteroid spine bases, one on each cardinal extremity, one on posterior part of each flank, and one on each side of the trail.

The distribution of these spine bases is constant but the latter two pairs are sometimes doubled.

Brachial valve interior with fine posterior median septum; muscle impressions obscure. Marginal ridges cross base of ears and bound visceral disc laterally. Rows of endospines developed on anterior part of visceral disc.

Discussion

Several species of small productids have been incorrectly named after this British form, but the specimens recorded here agree closely with the description give by MUIR-WOOD, 1928. Specimens from north-east Greenland recorded by

GRÖNWALL (1917, p. 579) and FREBOLD (1950) doubtfully belong to this species. A Greenland specimen in the Mineralogical Museum, Copenhagen, is larger than those described here. It is a pedicle valve showing the interior with a prominent adductor muscle platform resembling that of *Kozlowskia* FREDERICKS as figured by MUIR-WOOD and COOPER (1960, pl. 63, fig. 11). The forms from the Moscow basin figured by SARYCHEVA and SOKOLSKAJA (1952, pl. 45) have a well-defined sulcus and attain a width of 20 mm.

Occurrence

Eleven specimens from the Tårnkanten Sandstone, Tårnkanten, (X 609, S. M. E 18826–7). HOLTEDAHL's specimens were collected from the Scheteligfjellet Beds, Brøggerhalvøya. In Britain, *E. longispina* is found in the uppermost Viséan and Namurian.

Genus *Marginifera* WAAGEN, 1884

1884 *Marginifera* WAAGEN, p. 713.
1960 *Marginifera* MUIR-WOOD and COOPER, p. 206.
Genotype: *Marginifera typica* WAAGEN.

Marginifera? cf. *schellwieni* TSCHERNYSCHEW
Plate 3, figs. 21–26

Cf. 1902 *Marginifera schellwieni* TSCHERNYSCHEW, p. 648, pl. 58, figs. 9–12.
1952 *Marginifera pusilla* WANG, p. 347.
1958 *Marginifera pusilla* FORBES, p. 474.

Description

Outline sub-quadrate with greatest width (20 mm) at hinge line. Pedicle valve geniculate, with small, flattened umbo; wide, shallow median sulcus; and relatively large, flattened ears, clearly delimited from visceral disc. Shell surface worn but costae, 6–7 in 10 mm, visible on anterior part of visceral disc and trail, including sulcus. No evidence of concentric sculpture. Halteroid spine bases present on trail, one or more on each side of sulcus, and form curved row on flanks.

One specimen, E 17078, which may not be conspecific with the others, has plicae developed on the trail, and a sulcus V-shaped in cross section.

Discussion

Four damaged and exfoliated pedicle valves were identified as *M. pusilla* SCHELLWIEN by WANG 1952. SCHELLWIEN's original description and figures (SCHELLWIEN 1892, p. 20, pl. 4, figs. 18–21) depict two species, one of which (fig. 21) was named *M. schellwieni* by TSCHERNYSCHEW (1902, p. 649). *M. schellwieni* differs from *M. pusilla* in its larger dimensions (*pusilla* does not exceed 13 mm wide) and costate sulcus. As far as can be determined the specimens described here resemble *M. schellwieni*. *M. lebedevi* TSCHERNYSCHEW differs in having prominent concentric sculpture and a more regular longitudinal curvature,

although specimen E 17078 resembles this species in its narrower, V-shaped sulcus.

Occurrence

Upper Wordiekammen Limestone, Teltfjellet, Bünsow Land (S. M. E 17076–9). SCHELLWIEN's specimens were from the Fusulinakalk of the Carnic Alps and TSCHERNYSCHEW's from the "Schwagerinakalk" of the Urals and the Timan.

Subfamily Costispiniferinae MUIR-WOOD and COOPER, 1960

Genus *Liosotella* COOPER, 1953

1953 *Liosotella* COOPER, p. 36.
1955 *Liosotella* DUNBAR, p. 73.
1960 *Liosotella* MUIR-WOOD and COOPER, p. 227.

Genotype: *Liosotella rugosa* COOPER.

This genus was erected by COOPER for four new species of productids occurring in Middle Permian (Word) strata at El Antimono, Mexico. DUNBAR (1955) described another four new species and also put *Productus spitzbergianus* TOULA into the genus. Several species at present referred to *Marginifera* probably belong here. *Liosotella* differs from *Horridonia* in spine distribution, lower shell cavity, relatively smaller muscle impressions and in having specialized endospines in the interior of the brachial valve.

Liosotella pseudohorrida (WIMAN)
Plate 3, figs. 27–34

? 1850 *Productus horridus* DE KONINCK, (not J. SOWERBY), p. 634, fig. 1.
1858 *Productus sulcatus* var. *borealis* HAUGHTON, part, p. 242, pl. 7, figs. 2–4.
? 1875 a *Productus spitzbergianus* TOULA, p. 144, pl. 1, figs. 8 a–d.
1875 c *Productus horridus* TOULA, p. 232, pl. 4, figs. 2 a–d.
1914 *Productus pseudohorridus* WIMAN, p. 74, pl. 17, figs. 1–11.
1917 *Productus pseudohorridus* GRÖNWALL, p. 586, pl. 29, figs. 6–10.
1931 *Horridonia pseudohorrida pinigaensis* LICHAREW, p. 38, pl. 3, figs. 24, 25 a–c.
1934 *Sowerbina nottiensis* FREDERICKS, p. 39, pl. 2, figs. 5–8.
1936 *Sowerbina pseudohorrida* FREDERICKS, p. 98, pl. 1, figs. 18–21.
1937 *Productus* (*Horridonia*) *pseudohorridus* FREBOLD, p. 23, pl. 10, figs. 3–4.
1937 *Marginifera involuta* FREBOLD (not TSCHERNYSCHOW), p. 40, pl. 10, figs. 1, 2, 2 a.
1937 a *Productus* (*Horridonia*) *pseudohorridus* STEPANOV, p. 120, 176, pl. 5, figs. 5–7.
1937 a *Productus* (*Avonia*) *walcottianus* STEPANOV (not GIRTY), p. 137, 179, pl. 5, figs. 11a–b.
? 1937 a *Productus* (*Marginifera*) *sublaevis* STEPANOV (not R. E. KING), p. 137, 179, pl. 2, figs. 1–2, pl. 5, figs. 8–10.
1938 *Horridonia pseudohorrida pinigaensis* MIRSHINK, p. 323, pl. 3, figs. 12–14, text fig. 2.
1939 *Productus* (*Horridonia*) *pseudohorridus?* LICHAREW and EINOR, p. 54, 206, pl. 10, figs. 4–5.
1958 *Productus* (*Horridonia*) *pseudohorridus* FORBES, p. 475.
1960 *Liosotella pseudohorrida* SOLOMINA, p. 38, pl. 5, figs. 1–4.

Type data

Lectotype (here selected): the specimen figured by WIMAN 1914, pl. 17, figs. 8–10.

Type locality: Bellsund, Spitsbergen.

Description

Shell quadrangular in outline, markedly concavo-convex. Posterior border produced laterally into short, slightly arched ears. Greatest width slightly anterior to hinge line or at hinge line. Pedicle valve with rounded geniculation about 15 mm from umbo. Narrow median sulcus often shallowing and broadening anteriorly. Umbo narrow, slightly inflated and transgressing hinge line. Brachial valve strongly concave with flat ears and low, rounded median fold.

Valves smooth posteriorly. Costae irregularly developed anterior to geniculation and numbering 5–12 at anterior margin. Plicae sometimes present on anterior slope of pedicle valve. Halteroid spine bases on pedicle valve only, 5–6 forming curved row at base of umbonal slope; others scattered on anterior slope.

Pedicle valve interior with short, posteriorly placed adductor muscle platform. Umbo thickened and divaricator muscle impressions restricted to short zone adjacent to anterior end of adductor platform. Brachial valve interior convex, with anterior median sulcus. Small, triangular adductor muscle impressions situated posteriorly and joined by a low medianly sulcate ridge to small trilobed cardinal process. Narrow breviseptum between adductor impressions terminates in posterior end of sulcus. Kidney-shaped brachial ridges lie opposite anterior end of septum. Anterior to these lie two transverse rows of 6–7 large endospine bases, running together laterally but not crossing median sulcus. Surface has numerous small pustules.

Discussion

This species has usually been described under the genus *Horridonia* due to the obscurity and irregularity of the costae and their absence from the posterior part of the valves. TOULA (1875 a) probably included it in *P. spitzbergianus*, which, from his description, would appear to be a senior synonym of *P. pseudohorridus* WIMAN. However, TOULA's figured specimen shows a more regular convexity, and more regular costae arising nearer the umbo, and in these respects it resembles *Liosotella proboscidea* sp. nov. TOULA (1875 c) re-identified *P. spitzbergianus* as a variety of *P. horridus*. WIMAN (1914, p. 84) said that TOULA's original specimen of *P. spitzbergianus* was indeterminate. TOULA's specimens are now missing, presumed lost, from the Natural History Museum, Vienna. As there is some doubt over the identity of his figured specimen with those described here, I have used WIMAN's name *pseudohorridus*.

TOULA compared *P. spitzbergianus* with *P. orbignyanus* DE KONINCK. The type specimen (examined as a plastotype) of DE KONINCK's Bolivian species is a worn pedicle valve. It has a shallower sulcus and more regular convexity than most specimens of *L. pseudohorrida* and more spine bases on the anterior and lateral slopes. KOZLOWSKI (1914) redescribed *P. orbignyanus*. His *P. orbignyi* var. *major* is nearest to DE KONINCK's original but has a more pronounced sulcus. A row of spines is present at the base of the umbonal slope as in *Liosotella*. Unfortunately no brachial valves are visible in the specimens.

HAUGHTON (1858) figured two productids, collected from Hillock Point, Melville Island, as *P. sulcatus* var. *borealis*. One of these is a specimen of *Horridonia horrida* (see discussion of *Horridonia timanica*). The other specimen, which HAUGHTON

described as a young individual, cannot be distinguished by its external characters from *L. pseudohorrida*. The name *borealis* should be applied to the "adult" specimen and thus becomes a junior synonym of *P. horridus*.

L. pseudohorrida from the river Pinega, with a strongly convex umbonal area and a relatively large number of spine bases, were distinguished by LICHAREW (1931) as mut. *pinigaensis*. Forms from the Kanin Peninsula with a narrower and less deep sulcus and smaller ears were described by FREDERICKS (1934) as *Sowerbina nottiensis*. In Spitsbergen *L. pseudohorrida* exhibits a variation which would include these named forms.

L. spitzbergiana DUNBAR (1955), from central east Greenland, is not conspecific with *L. pseudohorrida*. It shows some resemblance with TOULA's figured specimen of *spitzbergiana* but has larger ears, more regular costae beginning nearer the umbo, and a shallower sulcus.

Occurrence

Common in the Middle Brachiopod Chert and less frequently found in the Lower Brachiopod Chert of Spitsbergen. The specimens described here were collected from the following localities.

Spirifer Limestone, Kapp Wijk (S. M. E 18298–9); Garwoodtoppen (D. 09.19, 09.24, 09B2, 09B5, 09B15); Bjonahamna, Tempelfjorden (S.M.E 18876). Brachiopod Limestone, Heimberget, Oscar II Land (X 681). Lower Brachiopod Chert, Gipshuken (S.M.E 17653). Middle Brachiopod Chert, Gipshuken (S.M.E 17684–6, E 17688–94, E 17698–700, E 17702–3, E 17705–6, E 17709–10, E 18867, E 18810 –2). Brachiopod Chert, west of Thiisbukta, Kongsfjorden (S. M. E 18077–8); Garwoodtoppen (D. S 10, U 5); Pretender (D. M 9). Scree, Cepheusfjellet, Ny Friesland (S. M. E 18059–60). Moraine, Malte Brunfjellet (S. M. E 18816–7; X 299).

Outside Spitsbergen, *Liosotella pseudohorrida* is known from the Upper Permian of the Pinega River, the Belkovsk and Vorkutsk Series of Pai Choi, the Permian of the Kanin Peninsula and of Novaya Zemlya, the Upper Marine Series of northeast Greenland, and from Hillock Point, Melville Island.

Liosotella proboscidea sp. nov.

Plate 3, figs. 35–41. Fig. 10

1914 *Marginifera typica* var. *septentrionalis* WIMAN, (not TSCHERNYSCHEW), p. 78, part.
1958 *Productus* (*Horridonia*) *pseudohorridus* FORBES, (not WIMAN), p. 475, part.

Type data

Holotype: S. M. E 17707.

Paratypes: S. M. E 17687, E 17695, E 17701, E 17704, E 17708.

Type locality: Middle Brachiopod Chert, 148 m above the base of the Spirifer Limestone, Gipshuken, Bünsow Land, Spitsbergen.

Diagnosis

Finely costate *Liosotella*, the costae extending to within 2–3 mm of the umbo. Narrow, deep, median sulcus, shallowing anteriorly and replaced by a rounded fold on the anterior slope which lies opposite the median fold of the brachial valve forming a hollow tube with it.

Description

Strongly concavo-convex shell, rounded quadrangular in outline. Greatest width at hinge line. Pedicle valve umbo narrow, inflated and slightly overarching hinge line. Flanks steep, separated by narrow sulci from gently arched ears. Narrow median sulcus begins 2–3 mm anterior to umbo, shallows on anterior third of valve and is replaced by rounded fold which continues to anterior margin. Brachial valve with low, rounded median fold and flat ears.

At the anterior border the opposed folds at the pedicle and brachial valves form a hollow tube or proboscis, separated from the narrow shell cavity by a shelly partition.

Umbo, ears, pedicle sulcus and fold and brachial fold smooth; rest of shell with low, rounded costae, about 15 on each side of mid-line. Row of 4–5 spine bases along base of umbonal slope and scattered spine bases on flanks and anterior slopes of pedicle valve.

The internal characters are known only from serial sections (see Fig. 10). The pedicle valve appears to have a small median platform in the umbonal region. The brachial valve interior has a flat visceral disc with steeply inclined lateral areas. No median septum is visible. Lateral prominences on the anterior part of the visceral disc may be sections of the brachial ridges or of large endospines.

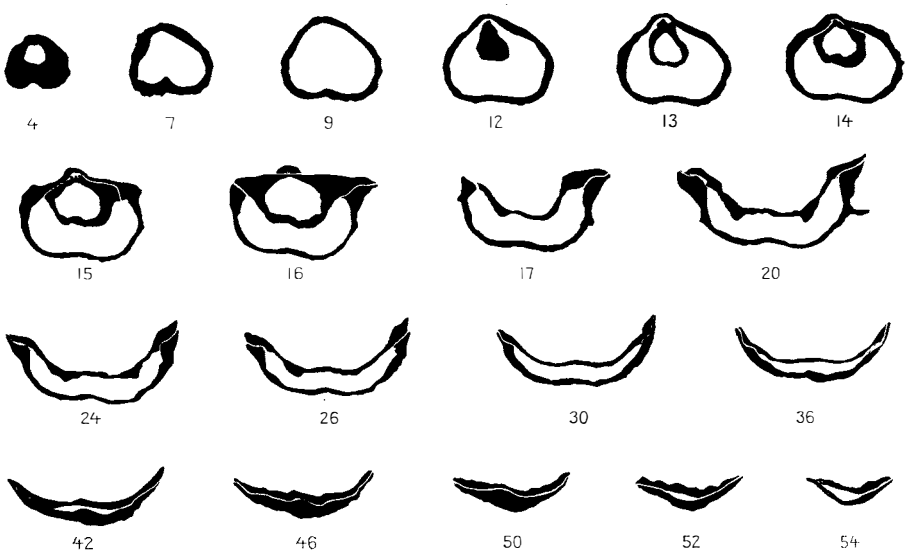

Fig. 10. *Liosotella proboscidea* sp. nov. Transverse sections of paratype, S. M. E 17708, × 1.5. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

Discussion

The pedicle valve of *Liosotella proboscidea* sp. nov. resembles that of *Marginifera septentrionalis* (TSCHERNYSCHEW) and records of the latter species from Spitsbergen (WIMAN 1914, p. 78, FREBOLD 1937, p. 38), may refer, at least in part, to the species described above. Three pedicle valves (R. M. S. Br. 1865 a–c) labelled *Marginifera typica* var. *septentrionalis* by WIMAN, one of which is figured on plate 5, figure 36, resemble the type specimens of *L. proboscidea* sp. nov. in the form of the ears, sulcus and anterior fold, and sculpture, differing only in their larger size. TSCHERNYSCHEW's figures of *septentrionalis* show pedicle valves with a costate sulcus, broader than that of *L. proboscidea* sp. nov., and with no sign of an anterior fold. A few pedicle valves from central east Greenland described as *M.* cf. *septentrionalis* (FREBOLD 1931, p. 25, pl. 3, figs. 2, 2 a–b; DUNBAR 1955, p. 80, pl. 5, figs. 5–6) also resemble *L. proboscidea* sp. nov. in general form and size but do not show an anterior fold.

Occurrence

Topotypes: (S. M. E 17696–7, E 18748–50). Brachiopod Chert, Akseløya, Bellsund, (R. M. S. Br. 1865 a–c).

Liosotella? robertiana (DE KONINCK)
Plate 4, figs. 1–7

1850 *Productus robertianus* DE KONINCK, p. 637, fig. 4.
? 1875 a *Productus wilczeki* TOULA, part, p. 141, pl. 1, figs. 6 a–b, d only.
1875 c *Productus longispinus* var. *setosus* TOULA (not PHILLIPS), p. 252, pl. 8, figs. 4 a–b.
? 1937 *Productus wilczeki* FREBOLD, p. 37, part.

Type data

Lectotype: DE KONINCK (1850) figured only one specimen which must be selected as the lectotype.

Type locality: Permian, Bellsund, Spitsbergen.

Description

Small concavo-convex shells with regular curvature and sub-circular outline. Hinge line forms greatest width. Ears small, strongly arched and merging with flanks. Pedicle valve with strongly incurved umbo, and narrow median sulcus, replaced by median fold at anterior border. Brachial valve concave with narrow median fold; shell cavity low.

Sulcus, fold and ears smooth. Rest of valves sculptured with relatively coarse plicae, clearly visible on internal moulds. Six umbonal plicae branch repeatedly to give 30–36 plicae at anterior margin, varying in width but finer than umbonal plicae. Spine bases present on flanks and cardinal extremities; distribution obscure.

The internal characters are unknown.

Discussion

This species resembles *Liosotella proboscidea* sp. nov. in form but is smaller, more convex and more distinctly sculptured. It is doubtfully assigned to *Liosotella* and may be unrelated to this genus.

The pedicle valve resembles that of *P. wilczeki* but the brachial valve of *wilczeki* (TOULA 1875 a, pl. 1, fig. 6 c) is quite distinct. The two valves figured by TOULA may not be conspecific: unfortunately his specimens are lost.

Occurrence

Permian, Bellsund (B. M. 65001 DE KONINCK collection); unlabelled (P. M. O. A 9803, A 9807).

Two internal moulds of pedicle valves (P.M.O. A 9813, A 9963) from the Permian of Hornsund, labelled *Productus wilczeki* by FREBOLD, are doubtfully assigned to *Liosotella? robertiana.*

Subfamily Probolioniinae MUIR-WOOD and COOPER, 1960

Genus *Probolionia* COOPER, 1957, p. 27

This genus was proposed for Marginiferidae characterized by:

elongate, strongly sulcate shell, costellate and posteriorly reticulate ornament, few scattered spines, six symmetrically placed, one on each cardinal extremity, one on each flank, and two on front of venter below geniculation and on either side of sulcus, this spine arrangement sometimes repeated in successive growth stages; trilobate, sessile cardinal process; internal, much thickened rim resembling diaphragm, bearing numerous long, subparallel trails. (MUIR-WOOD and COOPER 1960, p. 238).

Genotype: *Probolionia posteroreticulata* COOPER

Probolionia involuta (TSCHERNYSCHEW)
Plate 4, figs. 8–14

1902 *Marginifera involuta* TSCHERNYSCHEW, p. 645, part, pl. 36, figs. 7, 9, only, pl. 58, figs. 4–6, text-fig. 82.
1914 *Marginifera involuta* WIMAN, p. 77, pl. 19, figs. 1–11.
? 1914 *Marginifera typica* var. *septentrionalis* WIMAN, (not TSCHERNYSCHEW), p. 78, part.
1916 *Marginifera involuta* TSCHERNYSCHEW and STEPANOV, p. 65, pl. 7, figs. 2–3.

Type data

Lectotype (here selected): the specimen figured by TSCHERNYSCHEW, 1902, pl. 36, fig. 7, pl. 58, fig. 5, text fig. 82).

Type locality: "Cora horizon", River Ai, Mjasnikow Island, U. S. S. R.

Description

Outline rectangular, length greater than width. Pedicle valve strongly convex with regular curvature sometimes interrupted by sharp bend in posterior half of visceral disc. Umbo small, narrow and inflated. Umbonal angle about 80 °. Deep,

narrow, rounded sulcus extending from about 5 mm behind umbo to anterior margin and increasing only slightly in width anteriorly. Visceral humps broad and rounded; lateral slopes vertical. Ears slightly arched and clearly delimited from flanks. Visceral cavity high. Brachial valve has slightly concave visceral disc with narrow median fold and oblique lateral folds at base of flat ears; and is sharply geniculated into a thick trail, longer than the length of the visceral cavity, and composed of several laminae.

Shell thin with poorly defined sculpture limited to external layers of shell. Most specimens partly exfoliated and appear smooth. Low, rounded, costae number 6–8 in 5 mm on visceral areas of both valves and are replaced on trail by low, obscure plicae. Rugae spaced similarly to costae, form reticulation on visceral disc of brachial valve. Spines sparsely scattered over pedicle valve and form row on flanks. Larger, halteroid, spine bases are present on cardinal extremities and flanks anterior to geniculation.

Pedicle valve interior not seen but no umbonal thickening apparent. Brachial valve interior has low rounded ridge bordering visceral disc, raised and crenulated to form ear baffles and sculptured on anterior section with minute elongate pustules: inner surface of trail with much coarser elongate pustules. Cardinal process appears bilobed. Short median septum confined to posterior half of visceral disc. Muscle impressions obscure. Anterior part of visceral disc pustulate; ears smooth.

Discussion

TSCHERNYSCHEW fully described and figured this species and pointed out its characteristic features. He described crenulated ridges at the bases of the ears in the interior of the pedicle valve. It is not known whether these are present in the specimens described here. A specimen he figures (pl. 36, fig. 13) as the internal mould of a pedicle valve has an angular sulcus and visceral humps and resembles *Marginifera? bicarinata* WIMAN. A specimen in the Riksmuseum, Stockholm (Br. 1369) was labelled *Marginifera typica* var. *septentrionalis* by WIMAN. It appears on external characters to be conspecific with *P. involuta.*

FREBOLD described, as *Marginifera involuta,* some specimens from the Brachiopod Chert of the Festningen profile (FREBOLD 1937, p. 40, pl. 10, figs. 1–2). These specimens, which I examined in Oslo, are quite distinct from this species and are clearly conspecific with *Liosotella pseudohorrida* (WIMAN).

Occurrence

The specimens described by WIMAN and all those in the Sedgwick Museum (S. M. E 17948–62) are from the Cora Limestone landslip on the west side of Ymerdalen, Bjørnøya. Br. 1369 (see above) was collected from the Spirifer Limestone of Miseryfjellet. TSCHERNYSCHEW records the species from the Lower Permian of the Ural and the Timan. In arctic Canada it is recorded from Heiberg Land, and the Fielden Peninsula and Kapp Henry, Grinnell Land.

?Marginiferidae genus *incertae sedis*
"Productus" wilczeki TOULA

1875 a *Productus wilczeki* TOULA, p. 141, pl. 1, fig. 6 c, ?figs. 6 a–b, d.
1937 *Productus wilczeki* FREBOLD, p. 37, part, pl. 10, fig. 6.

Discussion

FREBOLD's specimen is a brachial valve, larger than that figured by TOULA but having a similar pattern of costae. Both authors figure an external mould which has bifurcating "costae"; but the costae of the valve, which are represented by grooves on the mould, increase in number by intercalation. TOULA stated (p. 141) that the sculpture of the brachial valve was characteristic and carefully described it. Thus the name *wilczeki* can be applied to the brachial valve, even if the pedicle valve figured by him is shown to belong to *Liosotella? robertianus* (DE KONINCK).

Another specimen P. M. O. A 5031) determined by FREBOLD shows part of a pedicle valve which appears to have a similar form and sculpture to that of the brachial valve and shows a long spine probably originating from the base of the umbonal slope.

Occurrence

Brachiopod Chert, fossil horizon 4, Festningen section, Isfjorden, (P. M. O. A 4980, A 5031).

Family Productidae GRAY, 184●

Genus *Productus* J. SOWERBY, 1814

1814 *Productus* SOWERBY, p. 153.
1930 *Productus* MUIR-WOOD, p. 102.
1960 *Productus* MUIR-WOOD and COOPER, p. 239.
Genotype: *Productus productus* (MARTIN).

MUIR-WOOD's (1930) study of the genotype established that it had an internal structure similar to that of *Diaphragmus* GIRTY and distinct from that of the semi-reticulate productids.

Productus anderssoni sp. nov.
Plate 4, figs. 15–27. Fig. 11

19●0 *Productus undiferus* ANDERSSON, (not DE KONINCK), p. 255.

Type data

Holotype: R. M. S. Br. 1342 c.
Paratypes: R. M. S. Br. 1343 b, e, g, h, j; Br. 1344 a–f, i, l.
Type locality: Ambigua Limestone, north-west of Ellasjøen, Bjørnøya.

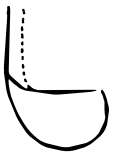

Fig. 11. *Productus anderssoni* sp. nov. Median longitudinal section of paratype R. M. S. Br. 1344 i, × 1.

Diagnosis

Small *Productus* with greatest width at anterior margin. Ears small, flat and triangular. Umbo small, pointed, not transgressing hinge line. Umbonal angle 105°. Sulcus very slight or absent. Brachial valve has flat visceral disc, geniculated at 90° to trail. Costae 11–16 in 10 mm, 20 mm from the umbo. Posterior part of pedicle visceral disc crossed by about 10 rugae and has scattered spine bases. Single row of cardinal spine bases and row crossing ears.

Description

Shell triangular in outline. Greatest width at anterior border and approximately equal to length (20–25 mm). Pedicle valve convex with flattened venter and steep lateral slopes. Shallow sulcus sometimes developed on anterior part of visceral disc. In longitudinal section, pedicle valve gently convex for about 8 mm from umbo, continuing as broad rounded geniculation into more convex anterior slope. Trail flattened but no specimens show it to be recurved. Hinge line extended into small, flat, triangular ears. Cardinal extremities obtuse. Brachial valve exterior has slightly concave visceral disc, geniculated into thin trail.

Both valves thin and shell cavity relatively large. Sculpture, clearly visible on internal moulds, of costae, rounded in cross section on visceral disc but flattened and broader on trail. Costae sometimes flexuous, varying in width, and bifurcating on anterior slope and trail. Rugae present on ears, posterior part of pedicle visceral disc and brachial visceral disc.

The internal characters are obscure due to the thinness of the valves. The shell breaks easily into two, the visceral parts of the valves becoming detached from the brachial visceral disc and pedicle trail, which are joined by the diaphragm.

Discussion

The specimens described here are all in the Riksmuseum, Stockholm. They were collected by ANDERSSON in 1899, and, although not labelled by him, are almost certainly the forms he listed as *Productus undiferus* DE KONINCK. They were labelled "*Productus* spec." by WIMAN.

Productus anderssoni sp. nov. may be distinguished from *P. productus* (MARTIN) by its smaller size and more prominent concentric rugae. In most external characters it resembles *P. elegans* NORWOOD and PRATTEN, the genotype of *Diaphragmus* GIRTY, but the latter has a more regular convexity and "upon the auriculations and the lateral slopes just inside the auriculations, is a group of rather fine, crowded spine bases, sometimes forty or more in number" (WELLER 1914, p. 137). These spine bases are clearly shown on the specimens figured by NORWOOD and PRATTEN (1855, pl. 1, figs. 7 a–c.).

Occurrence

The type locality and the Ambigua Limestone of Oswaldfjellet, Bjørnøya.

Family Echinoconchidae STEHLI, 1954
Subfamily Echinoconchinae STEHLI, 1954

Genus *Echinoconchus* WELLER, 1914

1914 *Pustula* THOMAS, part, p. 259.
1914 *Echinoconchus* WELLER, p. 138.
1960 *Echinoconchus* MUIR-WOOD and COOPER, p. 243.

THOMAS included this genus in *Pustula*. WELLER's diagnosis (1914, p. 138) is as follows:

Shell productoid in form and with internal characters as in the genus *Productus*. The external surface of the valves marked by more or less sharply differentiated concentric bands which commonly grow broader in passing from the beak to the outer margins, each band bearing numerous crowded, fine, appressed, imbricating spines, either subequal or unequal in size, which are produced from elongate, nodelike bases.

Remarks: This genus is proposed to include those shells which have heretofore been placed on the genus *Productus* in the group typified by *P. punctatus*. . . .

Echinoconchus was re-defined by MUIR–WOOD and COOPER (1960) who described the cardinal process as massive, recurved dorsally, and posteriorly trilobate, and the adductor muscle impressions as smooth and elongate.

Genotype: *Productus punctatus* J. SOWERBY.

Echinoconchus punctatus (J. SOWERBY 1822)

1911 *Productus punctatus* HOLTEDAHL, p. 35, pl. 3, figs. 4–5.
1914 *Pustula punctata* THOMAS, p. 303, pl. 17, figs. 16–19.
1917 *Productus punctatus* GRÖNWALL, p. 585, pl. 29, fig. 5.

This species is represented by one specimen from the Tårnkanten Sandstone of Robertsonfjellet (X 627). It is closely comparable with *E. punctatus* (SOW.) (S. M. E 9805–13), from the Carboniferous Limestone of Lowick, Northumberland, described by M'COY (1855, p. 469).

Occurrence

HOLTEDAHL recorded *E. punctatus* (SOW.) from the Scheteligfjellet Beds, Brøggerhalvøya. Other arctic occurrences are Amdrups Land, north-east Greenland (GRÖNWALL 1917), and Barents Islands, north-west Novaya Zemlya (Toula 1875 b, p. 551). GRÖNWALL's specimens, in the Mineralogical Museum, Copenhagen, are very similar to those from Spitsbergen.

The specimen figured by TSCHERNYSCHEW (1902, p. 296, pl. 57, fig. 12) is a different species. The concentric bands are obscure and the whole external surface of the pedicle valve is pustulate.

In Britain *E. punctatus* is found in the upper part of the Viséan, S_1 to D_3 and possibly higher. In the Moscow Basin it is recorded from the top of the Viséan and Namurian (SARYCHEVA and SOKOLSKAYA 1952, p. 103).

Echinoconchus elegans (M'Coy)

1855 *Producta elegans* M'Coy, p. 460, pl. 3H, figs. 4, 4 a–c.
1909 *Productus elegans* Lee, p. 170, pl. 2, figs. 38, 38 a–b.
1911 *Productus elegans* Holtedahl, p. 35, pl. 4, fig. 4.
1914 *Pustula elegans* Thomas, p. 292, pl. 17, figs. 1–4.
1952 *Echinoconchus elegans* Wang, p. 347.
1958 *Echinoconchus elegans* Forbes, p. 471.

A well-preserved pedicle valve (S. M. E 16998) from the base of the Wordiekammen Limestone, Campbellryggen, Bünsow Land, is closely comparable in form and sculpture with the lectotype (S. M. A 5721–2, see Thomas 1914, p. 294). The Spitsbergen specimen has a slightly greater curvature and a larger number of pustulate bands although both are 15 mm long. This may be explained if it is an older but relatively smaller shell. Another pedicle valve, (X 631) is from the Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land.

Occurrence

Holtedahl described this species from the Scheteligfjellet Beds, and Lee from the Carboniferous of Cape Cherney, Novaya Zemlya. In Britain, *E. elegans* is found in the upper part of the Viséan and in the Moscow Basin from the Viséan to the Moscovian.

Echinoconchus? isachseni (Holtedahl)
Plate 4, figs. 28–32

1911 *Productus isachseni* Holtedahl, p. 32, pl. 2, figs. 1–2.
1911 *Productus irginae* Holtedahl (not Stuckenberg), p. 34, pl. 2, fig. 3.
1911 *Productus* cf. *fasciatus* Holtedahl, p. 35, pl. 4, fig. 3.
1950 *Productus* (*Echinoconchus*) *fasciatus* Frebold (not Kutorga), p. 54, pl. 2, figs. 9, 9a–b.
?1952 *Echinoconchus fasciatus* Sarycheva and Sokolskaya, p. 99, pl. 18, No. 121.

Type data

Lectotype (here selected): P. M. O. A 4093, figured Holtedahl 1911, pl. 2, fig. 1.

Type locality: Scheteligfjellet, Brøggerhalvøya, Spitsbergen.

Description

Small productids with convex pedicle valve flattened medially, with steep flanks, and geniculated 12–15 mm from umbo. Posterior to geniculation, visceral area has triangular outline; umbo narrow, inflated; umbonal slopes steep; hinge line slightly extended to form small flat ears. Anterior to geniculation outline subrectangular, length exceeding width which is greatest at anterior border. Brachial valve, not seen on Holtedahl's specimens, has gently concave visceral disc, geniculated anteriorly into short trail.

Sculpture on pedicle valve of angular rugae, sometimes grooved along their length to form a double ridge, spaced 2–4 mm apart and curving slightly towards anterior border. Shell between rugae with 3–4 rows of fine spine bases. In several

specimens rugae become obscure posteriorly where spine bases form quincunces. Brachial valve sculpture similar.

Internal characters not known.

Discussion

The specimens described by HOLTEDAHL as *P. isachseni, P. irginae,* and *P.* cf. *fasciatus* are included in a single species which shows variation in the extent of the quincuncially arranged spine bases on the posterior part of the pedicle valve.

E. fasciatus (KUTORGA) is larger and has a more regular convexity than *isachseni*. *E. sterlitamakensis* STEPANOV, which has not been very clearly differentiated from *fasciatus*, has a similar sculpture to that on the anterior slope of *isachseni*.

Occurrence

HOLTEDAHL's specimens (P. M. O. A 4052–3, A 4058, A 4084–5, A 4093, A 4097, A 4109) were from the Scheteligfjellet Beds, Brøggerhalvøya. The only other specimen I have seen (S. M. E 17980) is from the Ambigua Limestone, north of Kapp Kåre, Bjørnøya. Another shell (S. M. E. 18037), doubtfully assigned to this species, is from the Cyathophyllum Limestone, station B 30, Polarisbreen, Ny Friesland.

Pustula THOMAS, 1914

1914 *Pustula* THOMAS, p. 259, part.
1960 *Pustula* MUIR-WOOD and COOPER, p. 250.
Genotype: *Producta pustulosa* PHILLIPS.

THOMAS's original diagnosis of *Pustula* included several kinds of pustulose productids now assigned to other genera (see MUIR-WOOD and COOPER 1960).

Pustula cf. *mosquensis* (IVANOV 1935)
Plate 4, fig. 33

Cf. 1952 *Buxtonia mosquensis* SARYCHEVA and SOKOLSKAYA, p. 101, pl. 16, No. 115.

Description

This form is represented by internal moulds of a single pedicle valve and an associated brachial valve.

Pedicle valve convex, sub-geniculate, with steep flanks. Umbo and ears obscured by matrix, but ears probably small. Median sulcus shallow. Sculpture, visible on internal mould, of eight narrow rugae, separating bands with small tangential spine bases which also appear to cross rugae. Shell thin except on umbo. Brachial valve (possibly not belonging to this species) with flat visceral disc and rounded spine bases in concentric bands.

Discussion

The pedicle valve agrees with the brief description and figures of SARYCHEVA and SOKOLSKAYA. IVANOV refers this species to *Buxtonia*. THOMAS (1914, p. 259)

defined *Buxtonia* as having ". . . . the young and adult stages characterised by a costate and spinous ornamentation, while in old age spinosity alone is developed". The sculpture of *mosquensis* appears to be of elongate spine bases only, characteristic of the genus *Pustula*.

Occurrence

In the Moscow Basin *P. mosquensis* ranges from the top of the Viséan (C_1^{st}) to the bottom of the Upper Carboniferous (C_3^{ks}).

The Spitsbergen specimen (S. M. E 17906) is from the Lower Gypsiferous Series, Ebbadalen, Billefjorden.

Pustula sp.

The posterior part of one pedicle valve which resembles a young *P. ovalis* (PHILLIPS) as figured by THOMAS (1914, p. 267, pl. 18, figs. 2–4) but there is no sign of a median sulcus in the Spitsbergen specimen.

B. M. B 17999; locality unknown. The lithology resembles that of the Lower Wordiekammen Limestone.

Genus *Bathymyonia* MUIR-WOOD and COOPER 1960, p. 244.

Genotype: *Productus nevadensis* MEEK.

Bathymyonia? sp.

Plate 5, figs. 3–5; plate 6, fig. 9

Two well-preserved internal moulds of pedicle valves, one with the brachial valve in place, and two silicified brachial valves show the diagnositic internal features of *Bathymyonia*. Another isolated external mould has finely-preserved sculpture closely comparable with this genus.

Description

Pedicle valve convex with broad, massive umbo and prominent median sulcus. Greatest width across middle of valve. Sculpture posteriorly of fine spine ridges, about 45 in 1 cm square, interrupted by 5–6 narrow transverse bands, marked only by crowded growth lirae; anteriorly of broader transverse bands with spines of two sizes, the smaller lying posteriorly and forming 5–6 rows. Fine, crowded growth lirae superimposed. Pedicle valve interior has posteriorly placed dendritic adductor muscle impressions on broad platform and, lateral to these, deep diductor muscle impressions, prominently ridged longitudinally. Anterior part of the valve pitted and obscurely ridged.

Brachial valve with flat visceral disc geniculated into short trail. Interior with massive trilobed cardinal process recurved dorsally, with short, broad median lobe and narrow lateral lobes converging on the external face. Broad lateral ridges along posterior border of valve. Median septum continues from thick shaft of cardinal process, two thirds of the length of visceral disc, tapering anteriorly. Adductor impressions posteriorly placed, elongate oval, lying close to median septum, divisible into larger dendritic posterior pair and smaller, smoother an-

terior pair. Brachial ridges extend laterally from anterior border of posterior adductor impressions to edge of visceral disc, recurving to form three quarters of a circle.

Occurrence

Spirifer Limestone, Bjonahamna (S. M. E 18455), west point of Lundenæringane, Bjørnøya (S. M. E 17923). Akseløya, Bellsund, (B. M. B 85024, B 85036), Garwoodtoppen, Kongsfjorden, (D. Q 13). Scree *ex* Brachiopod limestone, Skivefjellet, Oscar II Land (X 663).

Subfamily Waagenoconchinae MUIR-WOOD and COOPER, 1960

Genus *Waagenoconcha* CHAO, 1927

1927 *Waagenoconcha* CHAO, p. 85
1928 *Ruthenia* FREDERICKS, p. 789.
1960 *Waagenoconcha* MUIR-WOOD and COOPER, p. 252.
Genotype: *Productus humboldti* D'ORBIGNY

Ignorant of CHAO's monograph, FREDERICKS proposed the name *Ruthenia* for this genus and stated *Productus irginae* STUCKENBERG to be the genotype.

Waagenoconcha wimani (FREDERICKS)
Plate 5, figs. 1–2

1914 *Productus purdoni* WIMAN, (not DAVIDSON), p. 68, pl. 14, figs. 8–9.
1934 *Ruthenia wimani* FREDERICKS p. 28.
1936 *Productus wimani* STEPANOV, p. 120, pl. 4, figs. 1a–c.
1937 a *Productus* (*Waagenoconcha*) *wimani* STEPANOV, p. 126, pl. 6, figs. 1a–c.
1937 *Productus payeri* FREBOLD, (not TOULA), p. 19, part, pl. 2, fig. 1, pl. 3, fig. 3.

Type data

Lectotype (here selected): the specimen figured by WIMAN, 1914, pl. 15, fig. 1, pl. 16, figs. 1–2. This specimen is in the Riksmuseum, Stockholm.
Type locality: Spirifer Limestone, Nordkapp, Bjørnøya.

Description

Large, elongated shell with strongly convex pedicle valve and flat brachial valve. Pedicle valve has narrow, often shallow, median sulcus, narrow, inflated umbo and very steep flanks. Hinge line equals greatest width.

The pedicle valves are badly exfoliated but small areas of waagenoconchid sculpture are visible on the umbonal slopes.

Two specimens (S. M. E 18344, E 18351) are broader with more gently sloping lateral areas and may belong to another species.

Discussion

WIMAN called this large species *Productus purdoni* DAVIDSON. DAVIDSON's (1862, pl. 5, figs. 5a–b) and WAAGEN's (1884, pl. 73, figs. 1–3) figures of *P. purdoni* show a

much smaller shell, triangular in outline with a short hinge line, the greatest width lying in the anterior part of the valve. FREDERICKS subsequently renamed WIMAN's specimens *Ruthenia wimani*. FREBOLD however identified them with *P. payeri* TOULA. This name was also applied to a *Waagenoconcha* from central east Greenland (DUNBAR, 1955, p. 85). The specimens of *P. payeri* figured by TOULA are internal moulds of ventral valves, bearing no fragments of the original shell.

In the Natural History Museum, Vienna, three or four productid species are labelled *P. payeri*. The specimen figured by TOULA (1874, pl. 4, figs. 1a–b, 3) and another conspecific with it may be referred to *payeri*. The figured specimen differs from the internal mould of *W. wimani*. It resembles that of *Kochiproductus porrectus* (KUT.) in having a strongly inflated, elongate mould of the umbo, but I have not seen a sufficient number of specimens to be sure that *P. payeri* TOULA is conspecific with *K. porrectus* (KUT.). The other specimens are conspecific with *Waagenoconcha irginae* (STUCK.) and *Horridonia timanica* (STUCK.).

Occurrence

Common in the Spirifer Limestone of Bjørnøya, and less common in the Spirifer Limestone of Spitsbergen. Bjørnøya, Miseryfjellet, (S. M. E 17945–6, E 18344, E 18351). West point of Lundenæringane, (S. M. E 17922). Templet, (S. M. E 17466). Garwoodtoppen, Kongsfjorden, (D. 09B1).

Waagenoconcha irginae (STUCKENBERG, 1898, emend. TSCHERNYSCHEW)
Plate 5, fig. 7; plate 6, figs. 1–5

1874 *Productus humboldti* TOULA (not D'ORBIGNY), p. 282, pl. 2, figs. 3a–c.
1875 c *Productus humboldti* TOULA (not D'ORB.), p. 233, pl. 5, figs. 3a–b.
1902 *Productus irginae* TSCHERNYSCHEW, p. 619, pl. 30, figs. 3–4, pl. 52, figs. 1–4.
1914 *Productus irginae* WIMAN, p. 68.
1916 *Productus irginae* TSCHERNYSCHEW and STEPANOV, p. 55, pl. 6, figs. 2–4.
1936 *Productus irginae* STEPANOV, p. 120, pl. 3, fig. 3.
1937 a *Productus* (*Waagenoconcha*) *irginiformis* STEPANOV, p. 124, 178, pl. 6, figs. 4–5.
1937 *Productus* (*Waagenoconcha*) *irginae* FREBOLD, p. 18, pl. 5, fig. 8.
1937 *Productus* (*Waagenoconcha*) *humboldti* FREBOLD (not D'ORB.), p. 17, pl. 5, figs. 6–7.
1937 *Productus* (*Waagenoconcha*) *payeri* FREBOLD (not TOULA), p. 19, part, pl. 3, figs. 1–1a, pl. 4, figs. 2, 2a–b.
1939 *Productus* (*Waagenoconcha?*) *irginae* LICHAREW and EINOR, p. 33, pl. 3, figs. 12–13, pl. 4, fig. 1.
1939 *Productus* (*Waagenoconcha?*) *irginae* var. *irginaeformis* LICHAREW and EINOR, p. 35, 205, pl. 4, figs. 2–4.
?1950 *Productus* (*Waagenoconcha?*) *irginae* var. *irginaeformis* FREBOLD, p. 45, pl. 2, figs. 5, 5a 7, 7a, not 4.
1958 *Productus* (*Waagenoconcha*) *payeri* FORBES, p. 475.
1960 *Waagenoconcha payeri?* HARKER, p. 61, pl. 18, figs. 9–11.
1960 *Waagenoconcha humboldti* SOLOMINA (not D'ORB.), p. 28, pl. 1, figs. 4–6.
1960 *Waagenoconcha* cf. *humboldti* SOLOMINA, p. 30, pl. 1, figs. 7–9.
1960 *Waagenoconcha humboldti* var. *irginae* SOLOMINA, p. 31, pl. 2, figs. 1–4.

Description

Shell quadrate in outline with convex pedicle valve and flat brachial valve, geniculated into short trail. Pedicle valve has uneven curvature, with flattened

venter and steeply inclined flanks and anterior slope. Median sulcus narrow, ears small, and not clearly delimited from flanks. Hinge line not exceeding greatest width. Umbo inflated, narrow, pointed, slightly overarching hinge line. Shell substance thin and shell cavity large.

Both valves densely covered with recumbent spines, about 12 in 2 mm square, arranged in quincunces. Internal moulds show that pedicle valve interior has narrow median platform, broader in older specimens. Umbonal region smooth and divaricator muscle impressions lie on transverse bands with straight posterior and anterior borders.

Interior of brachial valve flat and covered with fine pustules becoming coarse anteriorly. Rounded lateral ridges along posterior border and median septum, prominent posteriorly becoming lower and disappearing in anterior half of valve. Adductor muscle impressions elongate oval and lie close to median septum. Cardinal process narrow, elongated.

Discussion

STUCKENBERG described two species, *P. irginae* and *P. gruenwaldti*. TSCHERNYSCHEW thought these were synonymous and since the latter name was a homonym of *P. gruenwaldti* KROTOW, retained the name *irginae* for the species.

The specimens TSCHERNYSCHEW described as *P humboldti* (1902, p. 620) may be internal moulds of young, thin shells of *P irginae* and thus appear to possess a more pronounced sculpture than the slightly worn shells of older specimens. STEPANOV (1937, p. 124, 178) recognized both of STUCKENBERG's species and proposed a new name, *irginaeformis* to replace *gruenwaldti*. *W. irginaeformis* has a slighter convexity and a less massive umbo than *W. irginae*. These differences can be seen in TSCHERNYSCHEW's figures (pl. 52; fig. 1, 3 – *irginae*; fig. 2, 4 – *irginaeformis*). Both forms are present in the collections from Spitsbergen and there are also intermediate types. The form of the umbo appears to be variable and unrelated to the convexity of the pedicle valve. I therefore include *irginaeformis* in the synonymy of *irginae*.

In central and north-east Greenland, a small species of *waagenoconcha* has been assigned to *humboldti* by FREBOLD (1931, p. 39, pl. 3, figs. 8, 8 a); to *irginae* var. *irginaeformis* by FREBOLD (1950, p. 45, pl. 2, figs. 5, 5 a, 7, 7 a) and to *Waagenoconcha* sp. by DUNBAR (1955, p. 88, pl. 8, figs. 7–16). This species is smaller than *irginae* and has a shorter hinge giving it a triangular outline. It resembles *W. montpelierensis* GIRTY.

W. irginae differs from *W. purdoni* (DAVIDSON) and *W. cylindrica* (WAAGEN) in its quadrate outline. The spines are finer and much closer set than those of *W. abichi* (WAAGEN). It has frequently been confused with *W. humboldti* but KOZLOWSKI's figures of this species indicate that it is smaller, more rounded in outline, has a shallower sulcus and coarser spines. KING (1931, p. 81) observed that *W. montpelierensis* (GIRTY) may be identical with *W. irginae*. However, it is doubtful whether KING's specimens belong to *W. montpelierensis*. This species (GIRTY 1910, pl. 2, figs. 5–6) is small with a slightly concave ventral valve and a very small, narrow, hooked umbo, similar to that of *Krotovia*. The specimens

KING figured have a more triangular visceral disc and coarser spines than those described here. *W. pseudoirginae* HUANG (1933, p. 52) closely resembles *irginae*.

Occurrence

W. irginae occurs in the Spirifer Limestone of Spitsbergen, Sassendalen (S. M. E 18322), Bjonahamna (S. M. E 18642–7), Usherfjellet (S. M. E 17496), Templet (S. M. E 17447–8, E 17450–5, E 17464–5), Tyrellfjellet (S. M. E 17609), Gipshuken (S. M. E 17535–6), station G 859, Oslobreen (S. M. E 18153–4), Kapp Wijk (S. M. E 18295–6); Spirifer Limestone of Bjørnøya, Miseryfjellet (S. M. E 18072), north side of Lakselva (S. M. E 17931), east bay of Herwighamna (S. M. E 17916); Cora Limestone of Bjørnøya, Ymerdalen (S. M. E 17969–70); Brachiopod Chert of Spitsbergen, Komarovfjellet, Oslobreen (S. M. E 18388), Gipshuken (S. M. E 18800), Templet (S. M. E 18229), Rundodden (S. M. E 18282), Kapp Wijk (S. M. E 18322), Skivefjellet (X 653, X 662, X 672); Scree, Gipsvika (S. M. E 18362).

In Russia it occurs in the Lower Permian of the Ural and the Timan and in the Talatinsk Series of Pai Choi (SOLOMINA 1960). In Novaya Zemlya it has been recorded from Loushkin Bay and on the east coast of the North Island between Capes Stary Novolok and Shevchenko. In arctic Canada *W. irginae* has been recorded from Great Bear Cape, Ellesmere Island; Heiberg Land; and Grinnell Peninsula, Devon Island.

Waagenoconcha sp. A
Plate 6, figs. 6–8

? 1916 *Productus waageni* BROILI, p. 14, pl. 118, figs. 1–5.

Description

Shell broader than long. Pedicle valve evenly convex, with broad sulcus. Brachial valve concave (?geniculated or crushed). Hinge line probably less than the greatest width of the shell although ears larger than those of *W. irginae*. Shell surface has well-developed growth lines and spines, ridges longer and less dense than those of *irginae*.

Discussion

There is a single well-preserved specimen (P. M. O. A 26260) of this species collected from the Brachiopod Chert of Rejmyrefjellet, Tempelfjorden by T. S. WINSNES. The original figures of *W. waageni* (ROTHPLETZ) are poor but the specimen is similar to those figured by BROILI from Timor.

Waagenoconcha sp. B
Plate 5, fig. 6

This species is represented by two external moulds of brachial valves (S. M. E 18189–90), similar in form to those of *W. irginae* but having longer spine ridges (cf. pl. 5, fig. 7). They were collected from the Lower Wordiekammen Limestone, Teltfjellet, Bünsow Land.

Family Buxtoniidae MUIR-WOOD and COOPER, 1960
Subfamily Buxtoniinae MUIR-WOOD and COOPER, 1960

Genus *Buxtonia* THOMAS, emend. MUIR-WOOD

1914 *Buxtonia* THOMAS, p. 259.
1928 *Buxtonia* MUIR-WOOD, p. 36.
1960 *Buxtonia* MUIR-WOOD and COOPER, p. 255.
Genotype: *Productus scabriculus* J. SOWERBY

Buxtonia sp.
Plate 7, figs. 10–11

Description

Moderately concavo-convex shells with strongly incurved umbo, and rounded geniculation 15 mm from umbo. Outline rounded triangular, greatest width near anterior border. Umbo narrow and inflated but slightly transgressing hinge line. Ears small, flanks steep, venter flattened and some specimens have shallow median sulcus on anterior slope. Brachial valve has sub-circular visceral disc, geniculated into short trail.

Pedicle valve posterior sculpture of fine, low costae, about 8 in 5 mm, bearing spine ridges angular in cross section. Concentric ribbing on flanks becoming obscure on venter. Continuous costae absent on anterior slope but large and small spine bases form concentric bands. Brachial valve has concentric ribbing more evident and costae less continuous. Internal characters not seen.

Discussion

All the specimens are damaged and more or less distorted, and more than one species may be present. They resemble *Buxtonia scabricula* (SOW.) in their sculpture but are smaller and have a more geniculate pedicle valve.

Occurrence

Basal Passage Beds, Sfinksen, Billefjorden (S. M. E 18121–4, E 18131–2); Tårnkanten Sandstone, Tårnkanten (X 605), Jutulslottet (X 617), Robertsonfjellet (X 628 (11) S. M. E 18835–6), Oscar II Land; no label (X 694).

Genus *Kochiproductus* DUNBAR, 1955

1924 *Tschernyschewiella* FREDERICKS (not VON TOLL, 1899), p. 20.
1955 *Kochiproductus* DUNBAR, p. 107.
1960 *Kochiproductus* MUIR-WOOD and COOPER, p. 259.
Genotype: *Productus porrectus* KUTORGA.

A diagnosis and discussion of this genus is given by DUNBAR. He improperly cited a new species *K. plexicostatus* as genotype of *Kochiproductus* which is only a substitute name for *Tschernyschewiella* FREDERICKS.

Kochiproductus porrectus (KUTORGA)
Plate 7, figs. 1–3

1844 *Productus porrectus* KUTORGA, p. 26, pl. 10, figs. 3a–b.
?1845 *Productus costatus* ROBERT, (not J. DE C. SOWERBY), pl. 19, fig. D.
?1874 *Productus payeri* TOULA, p. 277, part, pl. 4, figs. 1, 3 only.
1902 *Productus porrectus* TSCHERNYSCHEW, p. 634, pl. 32, fig. 4, pl. 55, fig. 1, pl. 56, fig. 4, pl. 62, fig. 2.
?1875c *Productus* cf. *scabriculus* TOULA, p. 252, pl. 8, fig. 6.
1916 *Productus porrectus* TSCHERNYSCHEW and STEPANOV, p. 63, pl. 5, pl. 8, fig. 5.
1937a *Productus* (*Buxtonia*) *freboldi* STEPANOV, p. 122, 176, part, pl. 2, fig. 4.
1960 *Kochiproductus freboldi* HARKER, p. 59, pl. 17, figs. 5–6.
1960 *Kochiproductus porrectus* SOLOMINA, p. 41, pl. 5, figs. 5–10, pl. 6, figs. 1–3.

Description

Outline sub-circular, greatest width at or immediately anterior to hing line Pedicle valve convex, flattening on anterior slope; anterior border reflexed. Umbo strongly inflated. Flanks steep; clearly delimiting sub-triangular visceral area from large, flattened ears, usually damaged or broken off. Broad median sulcus. Brachial valve has flat visceral disc, concave lateral and anterior borders and obscure, rounded median fold. Shell of both valves relatively thin.

Both valves sculptured with continuous costae, up to 1 mm wide, bifurcating anteriorly, and bearing spine ridges at regular intervals. Reticulated appearance, accentuated by concentric rugae on flanks of pedicle valve.

Interior of brachial valve has narrow, keel-like, median septum, 4 mm high posteriorly, decreasing anteriorly. Adductor muscle impressions small, elongate-oval, and lying adjacent to septum about half way along its length.

Discussion

KUTORGA figured a specimen showing the inflated umbo and the general nature of the sculpture but with the ears missing. This specimen was re-figured by DE KONINCK (1847, pl. 6, figs. 2a–b). TSCHERNYSCHEW illustrates the species more adequately and allows a close comparison to be made with the specimens described here. He illustrates the reflexing of the anterior border of the pedicle valve (his text figures 75, 76) and shows that the interior of the brachial valve has a thin median septum (his text figure 77 and pl. 32, fig. 4).

TSCHERNYSCHEW noted the close similarity of *porrectus* to *P. peruvianus* D'ORBIGNY but realized that the specimen of the latter figured by D'ORBIGNY (1842 pl. 4, fig. 4) was not well enough preserved to be used as a basis for comparison. I have examined a plaster cast of this specimen. It is a worn pedicle valve, without the ears. The form of this valve is very similar to that of Spitsbergen specimens. The surface however, although worn, shows that the spine bases are more rounded and the transverse element of the sculpture more pronounced. KOZLOWSKI's figures of *P. peruvianus* (KOZLOWSKI 1914 pl. 5, figs. 1–4) support these differences and clearly show the spine bases to be equidimensional, not elongated in the direction of the costae as in *porrectus*. KOZLOWSKI also illustrated the cardinal process and figured the posterior end of the rounded median septum with a median groove (KOZLOWSKI 1914, p. 14, text fig. 7). The internal mould

named *Productus payeri* by TOULA (see also under *waagenoconcha wimani* (FREDS.) resembles a Spitsbergen specimen (S. M. E 17492) of *K. porrectus*, which is also an internal mould with some of the shell preserved but with a damaged umbo.

FREBOLD (1931, 1933) described some shells from east Greenland as *P. porrectus*. STEPANOV (1937 a, p. 176) put these forms and the Spitsbergen specimens into a new species, *P. freboldi*, which differed from *P. porrectus* ". . . in the character of the sculpture, the longer hinge line, and the development of the ears." He figured a single pedicle valve of a Spitsbergen specimen which is probably conspecific with those described above. The status of *P. freboldi* as a distinct species was doubted by FREBOLD (1942, p. 28). He recognized the east Greenland forms as varietally different from *P. porrectus* but figured one specimen with large rounded spine bases as *P. freboldi* (1942, pl. 3, fig. 3). This is quite unlike STEPANOV's figured specimen of *freboldi*. DUNBAR (1955, p. 109) has shown that the east Greenland specimens are characterized by their anastomosing costae and has named the species, *Kochiproductus plexicostatus*.

The other arctic forms, in my opinion, cannot be distinguished from *porrectus*. The relatively thin shell of this species is easily distorted and the appearance of the ears varies with their state of preservation.

Occurrence

TSCHERNYSCHEW recorded *K. porrectus* from the Lower Permian of the Ural and Timan; it occurs in the Talatinsk Series of Pai Choi (SOLOMINA 1960). In Spitsbergen it appears to be restricted to the Spirifer Limestone. STEPANOV recorded it from Kapp Starostin, Isfjorden. The present specimens are from Barkovfjellet (S. M. E 18329); Usherfjellet, Bünsow Land (S. M. E 17492); Bjonahamna, Tempelfjorden, (S. M. E 18497–505); west ridge of Skedvifjella (S. M. E 18375). Three other specimens, doubtfully referred to this species, are from Templet, Tempelfjorden (S. M. E 17420); Skivefjellet, Oscar II Land (X 683); and the Spirifer Limestone at Herwighamna, Bjørnøya (S. M. E 17918).

In arctic Canada, *K. porrectus* has been collected from Great Bear Cape, Ellesmere Island (TSCHERNYSCHEW and STEPANOV 1916); and from Grinnell Peninsula, Devon Island. (HARKER 1960).

In Asia the species has been described from Kham Keut, Laos (MANSUY 1913); Afghanistan (REED 1931 b); Chitral (REED 1925); and the Maping Limestone of Kwangsi (GRABAU 1936). The specimens figured by these authors are poorly preserved and cannot be identified with *porrectus* with any certainty.

Subfamily Juresaniinae MUIR-WOOD and COOPER, 1960

Genus *Juresania* FREDERICKS, 1928

1928 *Juresania* FREDERICKS, p. 792.
1932 *Juresania* DUNBAR and CONDRA, p. 192.
1960 *Juresania* MUIR-WOOD and COOPER, p. 266.
Genotype: *Productus juresanensis* TSCHERNYSCHEW.

Juresania juresanensis (TSCHERNYSCHEW)
Plate 4, figs. 34–37

1902 *Productus juresanensis* TSCHERNYSCHEW, p. 276, 620, pl. 29, figs. 1–2, pl. 47, figs. 1–2, pl. 53, fig. 4.
1924 *Productus* cf. *nebrascensis* HOLTEDAHL, p. 17, pl. 20, figs. 4–5.
1932 *Productus* (*Juresania*) *juresanensis* FREBOLD, p. 24, pl. 1, figs. 6–7.
1958 *Productus* (*Waagenoconcha*) *humboldti?* FORBES, p. 473.

Type data.

Lectotype (here selected): the specimen figured by TSCHERNYSCHEW 1902, pl. 47, fig. 2.

Type locality: Sakmarian, River Juresan, two miles below Basrakova, U. S. S. R.

Description

Shell thin, sub-triangular in outline with greatest width near anterior border. Pedicle valve convex with inflated and strongly incurved umbo, shallow median sulcus and vertical flanks; produced anteriorly into short trail. Hinge line short, ears small, flat, and perpendicular to umbonal slopes. Brachial valve geniculate with flat visceral disc, broad low median fold and two oblique lateral folds, diverging from centre of hinge line and running parallel to base of ears.

Sculpture, present on both valves, of recumbent spines of two sizes, posteriorly arranged in irregular rows, anteriorly forming concentric bands of one row of large spines followed by 1–2 rows of smaller spines. Bands separated by narrow ridges and anterior sculpture resembles that of *Echinoconchus*. Numerous fine growth lirae superimposed on sculpture.

Interior of pedicle valve not seen. Interior of brachial valve of one specimen shows cardinal process with bilobed shaft, broken off anteriorly, supported by stout lateral ridges extending along the posterior border and tapering laterally.

Discussion

This species is similar to *J. nebrascensis* (OWEN). It may be distinguished by the greater convexity of the pedicle valve, narrower and more incurved umbo and the greater size difference between the two kinds of spines. The outline is elongated and sub-triangular, whereas *J. nebrascensis* has a sub-circular outline. As far as can be seen the internal characters agree with those of *Juresania nebrascensis* figured by MUIR-WOOD and COOPER (1960, pl. 79, fig. 14, pl. 80, figs. 2, 7, 8, 11, 14).

CHAO (1927, p. 81, pl. 8, figs. 4–8) described some forms from the Taiyuan Series as *Buxtonia juresanensis*. These were named *J. chaoi* by FREDERICKS (1928, p. 323) and later LICHAREW (1937, p. 115) assigned them to two varieties, *chaoi* and *taiyuanensis*, of *Pustula juresanensis*. They are very close to TSCHERNYSCHEW's species, differing only in the more transverse shape of the shell and larger ears.

Occurrence

TSCHERNYSCHEW recorded this species from the Lower Permian of Timan. HOLTEDAHL recorded it from the northern Krestovii Island, west-north-west of the Pankratyeff Peninsula, Novaya Zemlya. Frebold's specimens are from the "Red Series" of Wollaston Foreland, central east Greenland. In Spitsbergen it occurs in the Upper Wordiekammen Limestone of Bünsow Land at Gipsvika (S. M. E 17386–9, E 18263–5, E 18771), and Brisingefjellet (S. M. E 17341).

A specimen (P. M. O. A 28333) was collected by HOLTEDAHL from Garwoodtoppen, north-east of Kongsvegen.

Family Dictyoclostidae STEHLI, 1954
Subfamily Dictyoclostinae STEHLI, 1954

Genus *Dictyoclostus* MUIR-WOOD, 1930

1930 *Dictyoclostus* MUIR-WOOD, p. 103.
1945 *Dictyoclostus* MILORADOVICH, p. 496.
1949 *Dictyoclostus* SARYCHEVA, p. 88.
1960 *Dictyoclostus* MUIR-WOOD and Cooper, p. 269.
Genotype: *Productus semireticulatus* (MARTIN)

The genus *Dictyoclostus* has been emended by SARYCHEVA (1949) and MUIR-WOOD and COOPER (1960) to include only a small number of the species originally attributed to it.

Among the Spitsbergen species, one, possibly two, may be included in *Dictyoclostus* (*sensu* MUIR-WOOD and COOPER 1960).

Dictyoclostus pinguis MUIR-WOOD

1928 *Productus pinguis* MUIR-WOOD, p. 104, pl. 5, figs. 1, 2a–d, 3, pl. 6, fig. 1.
1930 *Dictyoclostus pinguis* MUIR-WOOD, p. 103.
1952 *Dictyoclostus pinguis* SARYCHEVA and SOKOLSKAYA, p. 142, pl. 38, No. 191.

Description

Large, quadrate in outline, wider than long. Pedicle valve geniculated to form trail. Umbo broad, venter broad and flat, flanks vertical, abruptly adjoining small, flat ears. Sculpture of regular costae, nine in 10 mm, 50 mm from umbo. Umbonal slopes crossed by about 20 rugae, posterior of which cross venter.

This species is represented by a single exfoliated specimen which appears conspecific with S. M. A 5796–7, identified by MUIR-WOOD as *D. pinguis*.

Occurrence

The specimen (S. M. E 18447) is from the Ambigua Limestone of Kobbebukta, Bjørnøya. It appears to be the only record of this species from the arctic. *D. pinguis* occurs in the Moscow basin, where it ranges from C_1^{st} to C_1^{prt} (i. e. uppermost Viséan to Namurian). In Britain it occurs in D_2, uppermost Visćan.

Dictyoclostus? aff. *inflatiformis* IVANOV, 1935
Plate 8, fig. 6

Description

Small dictyoclostid with maximum width of about 35 mm at or immediately posterior to hinge line. Pedical valve regularly convex, longitudinally and transversely. Umbo small, pointed, slightly inflated and scarcely transgressing hinge line; umbonal angle about 110°. Flanks slope gradually into large, flattened ears. Sulcus absent; slight median depression on anterior slope. Brachial valve has slightly concave visceral disc, geniculated into trail, damaged on the specimen. Sculpture of costae numbering 16 in 10 mm, 10 mm from the umbo and 12 in 10 mm, 20 mm and 30 mm from the umbo. About 12 relatively broad rugae, prominent on ears and flanks, more obscure on visceral disc. No spine bases evident.

Discussion

This species is represented by one fairly complete specimen (S. M. E 17988), collected from the Ambigua Limestone, north of Kapp Kåre, Bjørnøya. It resembles *D. inflatiformis* as figured by SARYCHEVA and SOKOLSKAYA (1952, p. 139, pl. 39, No. 196) but is smaller and shows no evidence of spines at the base of the ears.

D. inflatiformis occurs in the Upper Moskovian and Upper Carboniferous of the Moscow Basin.

Genus *Antiquatonia* MILORADOVICH, 1945, emend. SARYCHEVA, 1949

1945 *Antiquatonia* MILORADOVICH, p. 499.
1949 *Antiquatonia* SARYCHEVA, p. 167.
1960 *Antiquatonia* MUIR-WOOD and COOPER, p. 270.

Diagnosis

SARYCHEVA (1949, p. 167) gives the following diagnosis, translated from the Russian:

Brachiopod from small to large dimensions, with extremely convex ventral and articulate dorsal valve. Visceral cavity usually high; well-developed ears immediately separated from the visceral part by oblique folds covered with a row of coarse spines. In addition the spines form 1–2 rows along the hinge and are distributed over the whole of the ventral valve. The ribbing is clearly defined and characteristic of individual species. The concentric folds are well developed, but neither the ribs nor the folds extend across to the ears where only spines are distributed. The internal structure is normal for all semireticulate productids. A characteristic feature among many species is the presence on the dorsal valve of two pairs of adductors, the anterior pair of which have a relief which is less dendritic or smooth. There are no kinds of marginal lamellate formations present.

Genotype: *Productus antiquatus* J. SOWERBY.

Discussion

This genus was previously included in *Dictyoclostus*. Its distinction from that genus is based largely on the sculpture of the umbonal slopes and ears of the

pedicle valve. The folds that separate the ears from the visceral part of the pedicle valve were described by GIRTY (1935) and were termed pre-aural ridges by MILORADOVICH (1945).

Antiquatonia prikschiana (YANISCHEVSKY, 1935)
Plate 7, figs. 7–9

1949 *Antiquatonia prikschiana* SARYCHEVA p. 221, pl. 29, figs. 5–9.
1952 *Antiquatonia prikschiana* SARYCHEVA and SOKOLSKAYA, p. 149, pl. 43, No. 219.

Description

Small, width 20–25 mm. Pedicle valve strongly convex, geniculate, with steep umbonal and lateral slopes. Umbo small, inflated and slightly overarching hinge line. Ears small, flattened, not sharply demarcated from visceral disc. Sulcus absent. Brachial valve geniculate. Visceral cavity large. Trail developed. Both valves sculptured with prominent costae, enlarging anteriorly, about 15 in 10 mm, 10 mm from the umbo and 7–9 in 10 mm at anterior margin where costae vary in width up to 1 mm and are roof-shaped in cross section. Rugae on visceral disc of brachial valve but poorly developed on pedicle valve. Numerous spine bases on pedicle valve especially on trail and flanks, arising from costae and not exceeding 0.5 mm in diameter. Double row of spines present on low fold at base of ears.

Discussion

This species can be distinguished from other small species of *Antiquatonia* by the absence of a sulcus in the pedicle valve and in the nature of the costae. *A. gracilis* has much finer costae on the posterior part of the pedicle valve. *A. abrami* is smaller and has a coarser costation on the pedicle valve visceral disc.

The description of *A. prikschiana* given by SARYCHEVA and SOKOLSKAYA (1952, p. 149) is applicable to the Spitsbergen specimens, although the latter are slightly larger. However, no Russian specimens have been seen and it is possible that the Spitsbergen species is distinct.

Occurrence

This species occurs in the uppermost Viséan (C_1^{vn-tr}) of the Moscow Basin. The Spitsbergen specimens are from the Tårnkanten Sandstone of Jutulslottet (X 615(2)), and Robertsonfjellet (X 629(8), S. M. E 18837–8), Oscar II Land.

Antiquatonia cf. *serenensis* SARYCHEVA
Plate 7, figs. 4–6

cf. 1949 *Antiquatonia serenensis* SARYCHEVA, p. 213, pl. 28, figs. 5–8, pl. 29, figs. 1–4.
cf. 1952 *Antiquatonia serenensis* SARYCHEVA and SOKOLSKAYA, p. 149, pl. 43, No. 218.

Description

Pedicle valve flattened posteriorly, geniculated across visceral disc, with long, gently convex trail, sometimes with obscure median sulcus. Venter broad and

flattened; flanks short and vertical. Ears small, not completely preserved. Greatest width (25 mm) anteriorly. Brachial valve geniculate.

Sculpture of costae, increasing slightly in width anteriorly, numbering 20 in 10 mm, 10 mm from the umbo, and 12–14 in 10 mm, 20 mm from the umbo. Rugae cross venter posterior to geniculation. Spine bases scattered on pedicle valve.

Discussion

As far as can be judged from the limited material available, the specimens described above resemble *A. serenensis* in their external characters, although the distribution of spines on the posterior part of the pedicle valve is not clear.

Occurrence

Basal Passage Beds, Sfinksen, Billefjorden (S. M. E 18135–6); Passage Beds, Jacksonfjellet (S. M. E 17208); Tårnkanten Sandstone, Robertsonfjellet (X 630(2)).

A. serenensis is found in the middle Viséan of the Moscow Basin.

Genus *Pugilis* SARYCHEVA, 1949

1949 *Pugilis* SARYCHEVA, p. 104.
1952 *Pugilus* SARYCHEVA and SOKOLSKAYA, p. 77, 140.
1960 *Pugilis* MUIR-WOOD and COOPER, p. 281.
Genotype: *Producta pugilis* J. PHILLIPS.

Pugilis sp.

Plate 7, figs. 14–15. Fig. 12

Description

Medium-sized shells, about 45 mm in width, with quadrate outline, hinge equalling greatest width. Pedicle valve strongly convex, extending anteriorly as long, flattened trail. Flanks steep, sub-parallel. Umbo low, not overarching hinge line; umbonal angle 110°. Median sulcus shallow, obscure on trail. Ears small, triangular, flattened. Brachial valve concave, geniculated into long trail. Sculpture of low, rounded costae, 14–16 in 10 mm, 20 mm from umbo, remaining constant in width. Irregular plicae 2–3 mm wide superimposed on trail. About 25 rugae on ears and umbonal slopes, crossing venter in posterior part of visceral disc. Small spine bases scattered abundantly on pedicle valve, grouped on ears, forming cardinal row, and row at base of ears. Internal characters not seen.

Discussion

In their external characters, five specimens resemble the genotype, *P. pugilis*, but are not well enough preserved to be compared in detail with that variable species. The 10 species of *Pugilis* from the Moscow Basin described by SARYCHEVA all appear to be closely related and may be variants of *P. pugilis* (MUIR-WOOD and COOPER 1960, p. 283).

Occurrence

Tårnkanten Sandstone, Jutulslottet (X 623(3), S. M. E 18834), locality unknown (X 693(2)). *Pugilis* occurs in the Tournaisian, Viséan, and Namurian of Europe and the upper part of the Lower Carboniferous in the Moscow Basin.

Fig. 12

Fig. 13

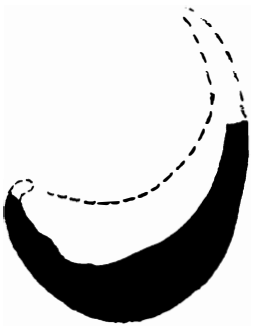

Fig. 14

Fig. 15

Fig. 12. *Pugilis* sp. Median longitudinal section of X 623, × 1.
Fig. 13. *Reticulatia holtedahli* sp. nov. Median longitudinal section of S. M. E 18129, × 1.
Fig. 14. *Chaoiella?* sp. Median longitudinal section of S. M. E 17502, × 1.
Fig. 15. *Costinifera arctica* (WHITFIELD). Median longitudinal section of S. M. E 18335, × 1.

Genus *Reticulatia* MUIR-WOOD and COOPER 1960, p. 284.

Genotype: *Productus huecoensis* R. E. KING, 1931 (*Dictyoclostus americanus* DUNBAR and CONDRA, 1932, not *Dictyoclostus americanus* SWALLOW, 1863).

Reticulatia holtedahli sp. nov.
Plate 8, figs. 1–5. Fig. 13

Type data

Holotype: S. M. E 18723.

Paratypes: S. M. E 17224–33, E 18700–22, E 18724–45.

Type locality: shore exposure of the Passage Beds on the east side of Petuniabukta, Billefjorden, Spitsbergen.

Description

Large, non-geniculate dictyoclostid, quadrate in outline, with hinge line equal to greatest width. Visceral cavity low. Pedicle valve strongly convex with regular curvature, extending anteriorly as a long, sometimes reflexed trail. Venter broad, with or without shallow median sulcus. Flanks steep, subparallel. Umbo broad, slightly over-arching hinge line; umbonal angle 115°. Ears large, flattened, triangular. Narrow ginglymus often obscure due to crushing of thin shell. Brachial valve strongly concave, with flattened or reflexed ears.

Both valves with irregular, rounded costae, numbering about 12 in 10 mm, 20 mm from umbo and frequently bifurcating on flanks and trail, crossed by numerous rugae in posterior half of valve, forming prominent reticulation. Spine bases scattered on pedicle valve, arising from costae and not exceeding 1 mm in diameter except on trail where about 10 large spine bases each disrupt 3–4 costae. Two rows of spine bases on ears.

Interior of pedicle valve unknown. Interior of brachial valve has narrow median septum, extending anteriorly at least three quarters length of visceral disc. Lateral ridges short. Cardinal process bilobed?; shaft broad, flat, grooved posteriorly. Endospines on anterior part of visceral disc, numerous on trail. Details of muscle impressions and brachial ridges obscured by external sculpture crushed through thin shell.

Discussion

This species is named in honour of Professor OLAF HOLTEDAHL. In external characters it agrees with those given in the description of *Reticulatia* (MUIR-WOOD and COOPER 1960, p. 284). An external cast of the cardinal process appears bilobed on its posterior face but this may be due to imperfect preservation. The internal characters are otherwise typically dictyoclostid. No antron is present as in *Marginatia* MUIR-WOOD and COOPER 1960.

Reticulatia holtedahli sp. nov. has a finer costation and relatively larger ears than *R. huecoensis*. A few specimens in the Mineralogical Museum, Copenhagen, collected from the Lower Marine Series of Amdrup Land, north-east Greenland and figured by FREBOLD (1950, p. 56, pl. 1, fig. 2, not 2 a, pl. 3) as *Productus* sp. indet. (*semireticulatus* group) resemble *R. holtedahli* sp. nov. in curvature and sculpture of the pedicle valve. However, they are not well enough preserved to be included in this species with certainty.

Occurrence

Abundant in the Passage Beds of Billefjorden on the east shore of Petuniabukta (S. M. E 17724–33, E 18700–45), on Sfinksen (S. M. E 18129–30, E 18143), and at Rudmosepynten (S. M. E 18869). Also found in the Lower Gypsiferous Series, south of Kapp Scott, Billefjorden (S. M. E 17989), and on Odellfjellet (S. M. E 18754). A single specimen (S. M. E 18446), from the Ambigua Limestone of Kobbebukta, Bjørnøya, may belong to this species.

Reticulatia cf. *moelleri* (STUCKENBERG, 1898)
Plate 8, figs. 10–11; plate 9, fig. 8

Cf. 1902 *Productus moelleri* TSCHERNYSCHEW, p. 613, pl. 34, figs. 1a–c.
? 1924 *Productus moelleri* HOLTEDAHL, p. 17, pl. 20, figs. 11.
Cf. 1952 *Dictyoclostus moelleri* SARYCHEVA and SOKOLSKAYA, p. 138, pl. 39, No. 194.

Description

Pedicle valve quadrate in outline, strongly and evenly convex with shallow, narrow, sulcus and long trail. Umbo small, not over-arching hinge line; umbonal angle 100°. Hinge line equals greatest width; ears flat and triangular. Brachial valve concave; visceral cavity low. Both valves sculptured with low, rounded costae, about 0.5 mm wide on umbo, broadening to 1 mm wide on trail, where they number eight in 10 mm. Narrow rugae on posterior part of pedicle valve and visceral disc of brachial valve, broadening anteriorly and producing prominent reticulation. Spine bases scattered on flanks and trail of pedicle valve, cardinal row, and 1–2 rows at base of ears. Cardinal process short, broad and ? trilobed; other internal characters not seen.

Discussion

These shells agree in most characters with the description of *D. moelleri* given by SARYCHEVA and SOKOLSKAYA but are slightly larger and have a smaller umbo. TSCHERNYSCHEW's figured specimens show the prominent reticulation but have a deeper sulcus. *Productus leplayi* VERNEUIL has a very similar ornamentation but a more geniculate pedicle valve which is broader than long. HOLTEDAHL's specimen is incomplete.

Occurrence

Three specimens from scree: 133 m above the local base of the Carboniferous, W 102, Polarisbreen, Ny Friesland (S. M. E 18038); Wordiekammen, Billefjorden (S. M. E 18115), and Watsondalen, Bünsow Land (S. M. E 18272). The last two specimens were derived from the Wordiekammen Limestone.

TSCHERNYSCHEW recorded *P. Moelleri* from the Lower Permian of the Ural and it is found in the Moscow Basin in the upper part of the Moscovian C_2^{pd}, C_2^{m}, and Upper Carboniferous C_3^{ks}, C_3^{gj}.

Genus *Chaoiella* FREDERICKS, 1933

1933 *Chaoiella* FREDERICKS, p. 31.
1960 *Chaoiella* MUIR-WOOD and COOPER, p. 275.
Genotype: *Productus grünewaldti* KROTOW

Chaoiella cf. *grünewaldti* (KROTOW, 1888)
Plate 8, figs. 7–9

1902 *Productus grünewaldti* TSCHERNYSCHEW, p. 608, pl. 32, fig. 3, pl. 61, figs. 3, 5–7, pl. 62, figs. 4–5.
1911 *Productus boliviensis* HOLTEDAHL (not D'ORBIGNY), p. 30, pl. 3, fig. 1.

Description

Six pedicle valves with convex, rounded-triangular visceral disc, steep flanks and relatively small ears. Umbo narrow, slightly inflated, and slightly overarching hinge line; umbonal angle 80–90°. Long curved trail, broader than visceral disc; greatest width near anterior border. Sculpture of costae, absent on ears, numbering 10–11 in 10 mm on trail; rugae in posterior half of valve, crossing venter and forming reticulation; spine bases small, few, on flanks, trail and ears. Internal characters not seen.

Discussion

These specimens differ from *C. grünewaldti* in the smaller ears and more pronounced costation on the trail. The specimen in the Palaeontological Museum, Oslo, described by HOLTEDAHL as *P. boliviensis* appears conspecific with them. Four specimens in one block (P. M. O. A 28331) from the base of the Cyathophyllum Limestone, Kolosseum, Ekmanfjorden may be conspecific with those described above. Two of these shells show the brachial valve with a slightly concave visceral disc geniculated into a trail.

Occurrence

Cora Limestone, Ymerdalen, Bjørnøya (S. M. E 17964–8). Lower Wordiekammen Limestone, Gerardfjella, Tempelfjorden (S. M. E 17283).

Chaoiella grünewaldti appears to be widespread in the Upper Carboniferous and Permian of Asia. SARYCHEVA and SOKOLSKAYA (1952, p. 144) record it from the Moscovian of the Moscow Basin.

Chaoiella? cf. *taiyuanfuensis* (CHAO)

Plate 7, figs. 12–13

Cf. 1927 *Productus taiyuanfuensis* CHAO, p. 30, pl. 1, fig. 10, pl. 2, figs. 1–12, pl. 8, fig. 16.

Cf. 1939 *Productus* (*Productus*) *taiyuanfuensis* var. *tareianensis* EINOR, p. 126, pl. 2, fig. 6, pl. 3, figs. 1–3.

1952 *Dictyoclostus taiyuanfuensis* WANG, p. 347.

Description

Four damaged and partly exfoliated pedicle valves represent this species.

Visceral disc broadly triangular, geniculated into narrowly sulcate trail; greatest width, about 30 mm, near anterior border. Low, rounded costae on visceral disc and trail, numbering 10–12 in 10 mm. About 20 rugae, slightly broader than costae, cross venter of visceral disc. Internal characters not seen.

Discussion

These shells resemble EINOR's variety in their fine costation but his figures are poor. The specimens are not well enough preserved to be identified with any certainty.

Occurrence

Upper Wordiekammen Limestone, Teltfjellet, Bünsow Land (S. M. E 17070–3).

The specimens described by EINOR were collected from the Lower Permian of the Piassina river basin, western Taimyr Peninsula.

Chaoiella? sp.
Plate 9, fig. 1. Fig. 14

1958 *Productus boliviensis* FORBES (not D'ORBIGNY), p. 475.

Four incomplete pedicle valves, resembling *Costinifera arctica* in size, thick shell, narrow median sulcus, and sculpture, but with a more rounded geniculation and sloping flanks, merging into large, strongly arched ears, which give the valve a tranverse outline. Shells of this form have been previously referred to *Chaoiella boliviensis* although those figured by WIMAN as *boliviensis* belong to *Costinifera arctica* (WHIT.).

Occurrence

Spirifer Limestone, Gipshuken (S. M. E 17502–3), and Tyrellfjellet (S. M. E 18680), Bünsow Land.

Genus *Costinifera* MUIR-WOOD and COOPER, 1960, p. 277
Genotype: *Productus indicus* WAAGEN.

This genus was proposed for the large, spirally enrolled, coarsely costate dictyoclostids described by WAAGEN from the Productus Limestone of the Salt Range. Most of the diagnostic characters of *Costinifera* are present in the common arctic species described below.

Costinifera arctica (WHITFIELD)
Plate 9, figs. 2–6. Fig. 15

? 1875 c *Productus semireticulatus* TOULA, (not MARTIN), p. 234, pl. 6, figs. 1a–d.
1902 *Productus inflatus* TSCHERNYSCHEW, (not MCCHESNEY), p. 612, pl. 28, figs. 1–6.
1908 *Productus semireticulatus arcticus* WHITFIELD, p. 54, pl. 1, fig. 2, pl. 2, figs. 8–10.
1914 *Productus inflatus* WIMAN, (not MCCHESNEY), part, p. 66, pl. 14, figs. 1–2, pl. 15, fig. 5.
1914 *Productus boliviensis* WIMAN, (not D'ORBIGNY), p. 63, pl. 13, figs. 7–10.
1916 *Productus inflatus* TSCHERNYSCHEW and STEPANOV, (not MCCHESNEY), p. 30, pl. 5.
1917 *Productus inflatus* GRÖNWALL, (not MCCHESNEY), p. 578, pl. 29, figs. 17–19.
? 1931 *Productus arcticus* KING, p. 66, pl. 10, figs. 16–17.
1936 *Productus arcticus* STEPANOV, p. 115, pl. 1, figs. 1–4.
1937 a *Productus* (*Productus*) *arcticus* STEPANOV, p. 174, pl. 1, figs. 9–10.
1937 *Productus inflatus* TSCHERNYSCHEW (not MCCHESNEY), FREBOLD, p. 13.
1938 *Productus neoinflatus* LICHAREW, p. 90, pl. 21, figs. 2a–c, 3a–b.
1939 *Productus* (*Productus*) *arcticus* LICHAREW and EINOR, p. 47, pl. 7, figs. 10–11, pl. 8, fig. 4.
1950 *Productus arcticus* and *Productus neoinflatus* FREBOLD, p. 51, pl. 2, fig. 3.
1952 *Dictyoclostus uralicus* WANG (not TSCHERNYSCHEW), p. 347.
1958 *Productus inflatus* FORBES, (not MCCHESNEY), p. 475.
1960 *Dictyoclostus* cf. *neoinflatus* HARKER, p. 55, pl. 17, figs. 1–4.
1960 *Productus?* cf. *arcticus* SOLOMINA, p. 58, pl. 10, figs. 1–8.

Type data

Lectotype (here selected): the specimen figured by WHITFIELD, 1908, pl. 1, fig. 2, pl. 2, figs. 8–9.

Type locality: Cape Sheridan, north-east Ellesmere Island.

Description

This species is represented by about 70 specimens. Both valves are often preserved intact but the ears are generally missing. Several specimens are silicified and five of these were etched from the matrix with hydrochloric acid.

Large spirally enrolled shell, geniculated at about 30 mm from umbo. Posterior part of visceral disc triangular in outline. Umbo inflated, narrow, pointed; umbonal angle 100°. Venter flattened; flanks vertical or inflated remaining subparallel throughout length of shell. Narrow median sulcus developed about 10 mm from umbo, extending to anterior margin, and remaining constant in width. Ears large, strongly enrolled, extending at right angles to flanks and frequently broken off. Brachial valve with flat visceral disc becoming concave in older specimens, and low median fold; geniculated into long trail with more pronounced narrow median fold. Ears flat, separated from the visceral disc by more or less angular ridge.

Both valves sculptured with costae, numbering nine in 10 mm, radiating on ears, bifurcating on flanks and trail. Narrow rugae on brachial visceral disc and posterior part of pedicle visceral disc; not as prominent as costae. Small spine bases scattered on pedicle valve, concentrated on flanks and trail where they give rise to numerous long, erect halteroid spines.

Interior of pedicle valve has elongated, dendritic adductor muscle impressions on median platform, which merges anteriorly with angular median ridge. Diductor muscle impressions with straight posterior and anterior margins, marked with longitudinal ridges, and extending slightly anterior to adductor impressions. Interior of brachial valve with massive trilobed cardinal process, on broad, keeled shaft, confluent with posterior part of median septum. Septum low in centre of valve, enlarging near anterior end into keeled knob. Lateral ridges diverge slightly from hinge line and continue, recurving across base of ears, around lateral margin of visceral disc. Adductor impressions triangular, dendritic. Brachial ridges prominent, sub-circular, placed laterally.

Discussion

WIMAN (1914) described Spitsbergen specimens of this species as *P. inflatus* MCCHESNEY and *P. boliviensis* D'ORBIGNY, basing these identifications on TSCHERNYSCHEW's (1902) descriptions.

Productus inflatus MCCHESNEY is a Mississippian species from Indiana, U.S.A. The original description (MCCHESNEY 1867, p. 27) is incomplete. A single pedicle valve is figured. This is smaller, has much smaller ears and a more regular curvature than the Spitsbergen or Russian specimens. These differences were confirmed by COOPER (1944, p. 350, pl. 136, figs. 9–14), and MUIR-WOOD and COOPER (1960, p. 227, pl. 55, figs. 1–15) who assigned the species to a new genus *Inflatia* of the subfamily *Costispiniferinae*.

Productus boliviensis was first described from the Lower Permian of Yarbichambi, Bolivia. D'ORBIGNY's drawings (1842, pl. 4, figs. 5–9) show the pedicle valve to have a regular curvature, continued in the drawing through 360°. KOZLOWSKI's figures of Bolivian specimens also show no marked geniculation of

the pedicle valve. I have examined a plaster cast of one of D'ORBIGNY's original specimens. This is an imperfect pedicle valve with a more regular convexity and finer costae than any Spitsbergen specimens.

The specimens assigned to *P. boliviensis* by WIMAN appear to be those having some trace of the ears.

The Spitsbergen forms are conspecific with specimens from Cape Sheridan (82° 27′ N), Ellesmereland, described by WHITFIELD (1908, p. 54) as *Productus semireticulatus arctica*, although none of WHITFIELD's figured specimens have complete ears. STEPANOV (1937 a, p. 174) put the species into *Productus s.s.*, stating that a diaphragm was present. There is no evidence of this in the specimens I have seen. When sectioned along the mid-line, the prominent knob at the anterior end of the median septum may be mistaken for a marginal ridge but bears no resemblence to the thin diaphragm of *Productus s. s.*

FREDERICKS (1915, p. 46) divided TSCHERNYSCHEW's *P. inflatus* into two forms, designating these as sub-species of *P. genuinus* KUTORGA 1844, emend. TSCHERNYSCHEW 1902. According to STEPANOV (1934, p. 15), *P. genuinus orientalis* was distinguished by its coarser costation from *P. genuinus inflatus*. LICHAREW (1939) separated some of TSCHERNYSCHEW's *P. inflatus* as *Productus neoinflatus*, which differs from *C. arctica* only in its smaller ears (FREBOLD 1942, p. 24). It is doubtful whether *P. neoinflatus* LICHAREW is specifically distinct from *P. arcticus* WHITFIELD. FREBOLD (1942, p. 22) also discussed the status of *Productus arcticus* KING. He concluded that KING's species, recorded from the Word formation of Texas, was not conspecific with *Productus arcticus* WHITFIELD or with *P. inflatus* TSCHERNYSCHEW. KING's description agrees with the Spitsbergen forms although the ears are missing in his figured specimens. KOZLOWSKI (1914, p. 33) described, as *Productus inflatus* MCCHESNEY, a dictyoclostid present in the Lower Permian of Bolivia. This differs from *P. inflatus* TSCHERNYSCHEW in its smaller size and the more regular curvature of the pedicle valve. The interior of the brachial valve has a raised margin around the visceral disc. Asiatic forms of *P. inflatus* TSCHERNYSCHEW (e. g. CHAO, 1927, p. 36) are probably distinct and, if this is so, may be designated *Costinifera orientalis* (FREDERICKS).

Occurrence

In Svalbard this species occurs in the Lower Brachiopod Chert, forming shell banks in the Spirifer Limestone. All the specimens described here were collected from the Spirifer Limestone.

Spitsbergen, Tempelfjorden, Templet (S. M. E 18220–1, E 18227), Bjonahamna (S. M. E 18506–18); Gerardfjella (S. M. E 18873), Barkowfjellet (S. M. E 18330), Skedvifjella (S. M. E 18374); Bünsow Land, Usherfjellet (S. M. E 17493), Gipshuken (S. M. E 17504–6, E 17508–14, E 17583–6, E 18781–3), Tyrellfjellet (S. M. E 17109, E 17606–7, E 17617–23); Oscar II Land, Skivefjellet (X 640); Ny Friesland, Mertonberget (S. M. E 18035).

Bjørnøya, Miseryfjellet (S. M. E 17934–9), east bay of Herwighamna (S. M. E 17915, E 17917), Padda (S. M. E 18332–8).

C. arctica is widespread in the arctic Permian, but noticeably absent from central east Greenland. It appears to be related to the Salt Range dictyoclostids.

Costinifera cf. *uralica* (TSCHERNYSCHEW)
Plate 9, fig. 7

Cf. 1902 *Productus uralicus* TSCHERNYSCHEW, p. 612, pl. 32, fig. 1, pl. 33, fig. 1, pl. 62, fig. 1.
1937 *Productus uralicus* FREBOLD, p. 15, pl. 7, figs. 1–4, pl. 8, figs. 1–2.
?1937a *Productus* (*Dictyoclostus*) sp. STEPANOV, p. 175, pl. 2, fig. 1.

This large species is represented by four external moulds of brachial valves and three incomplete pedicle valves. It resembles gerontic specimens of *C. arctica* but has a coarser costation, five costae in 10 mm, and more spreading flanks. In size and external features the specimens resemble *Productus uralicus* TSCHERNYSCHEW. TSCHERNYSCHEW (1902, p. 359) recorded this species from Spitsbergen but the specimens were too poorly preserved to be figured by WIMAN (1914, p. 66). The specimens in the Riksmuseum, Stockholm, which TSCHERNYSCHEW may have seen, are probably conspecific with those described here. Those figured by FREBOLD are distorted and lack ears. *C. uralica* has not been recorded from Greenland or arctic Canada.

The specimens in the Sedgwick Museum are from the Middle Brachiopod Chert, Gipshuken (S. M. E 17651–2, E 18746). Five specimens in the British Museum, two of which are labelled "Carboniferous. Starotschin point. Ice-fjord. GARWOOD" were probably collected from the Brachiopod Chert.

Subfamily Horridoniinae MUIR-WOOD and COOPER, 1960

Genus *Horridonia* CHAO, 1927

1927 *Horridonia* CHAO, p. 25.
1928 *Sowerbina* FREDERICKS, p. 778.
1955 *Pleurohorridonia* DUNBAR, p. 89.
1955 *Sowerbina* DUNBAR, p. 95.
1960 *Horridonia* MUIR-WOOD and COOPER, p. 292.
Genotype: *Productus horridus* J. SOWERBY.

This genus was discussed by GOBBETT (1961). FREDERICKS proposed *Sowerbina* in ignorance of CHAO's work. It was recognized by DUNBAR (1955) as distinct from *Horridonia* CHAO. DUNBAR also proposed *Pleurohorridonia* for forms which I consider conspecific with *H. horrida* (J. SOWERBY).

Horridonia timanica (STUCKENBERG)
Plate 10, figs. 1–4

1875 *Productus timanicus* STUCKENBERG, p. 86, pl. 1, figs. 1–7.
1875 c *Productus horridus* var. *granuliferus* TOULA, p. 232, pl. 6, figs. 3a–c.
1901 *Productus granulifera* FRECH, p. 497, fig. 6.
1902 *Productus timanicus* TSCHERNYSCHEW, p. 638, pl. 30, fig. 5, pl. 57, figs. 1–6, text figs. 78, 79.
1908 *Productus borealis* WHITFIELD (not HAUGHTON), p. 55, pl. 1, pl. 2, fig. 11.
1914 *Productus timanicus* WIMAN, p. 75, pl. 17, figs. 19–21, pl. 18, figs. 1–6.
1914 *Productus inflatus* WIMAN (not MCCHESNEY), part, pl. 14, fig. 1, pl. 15, figs. 3, 5.

1916 *Productus timanicus* TSCHERNYSCHEW and STEPANOV, p. 64, pl. 6, fig. 6.
1917 *Productus timanicus* GRÖNWALL, p. 586, pl. 29, figs. 11–16.
1931 *Productus timanicus* FREBOLD, p. 22, pl. 2, figs. 1–5.
1934 *Ruthenia granulifera* FREDERICKS, p. 39, pl. 3, figs. 1–8, pl. 4, figs. 1–3.
1936 *Productus borealis* STEPANOV (not HAUGHTON), p. 116, pl. 2, figs. 1–4, pl. 3, fig. 1.
1937 a *Productus* (*Horridonia*) *borealis* STEPANOV (not HAUGHTON), p. 115, 175, pl. 4, figs. 1–3, pl. 5, figs. 1–4.
1937 *Productus* (*Horridonia*) *timanicus* FREBOLD, p. 21, pl. 4, fig. 4, pl. 7, figs. 2–3.
1942 *Productus* (*Horridonia*) *timanicus* FREBOLD, p. 14, pl. 1, figs. 1–3, pl. 2, figs. 1–2.
1950 *Productus* (*Horridonia*) *timanicus* FREBOLD, p. 52, pl. 2, figs. 1, 1a–b.
1952 *Horridonia timanica* WANG, p. 347.
1955 *Sowerbina maynci* DUNBAR, p. 97, pl. 13, figs. 1–9.
1955 *Sowerbina rudis* DUNBAR, p. 101, pl. 14, figs. 1–7, pl. 15, figs. 1–6.
1958 *Productus* (*Horridonia*) *timanica* FORBES, p. 475.
1960 *Horridonia borealis* SOLOMINA (not HAUGHTON), p. 34, pl. 3, figs. 3–6, pl. 4, figs. 1–3.
1960 *Horridonia borealis* var. *granulifera* SOLOMINA, p. 37, pl. 4, figs. 4–6.

Type data

Lectotype: the specimen figured by STUCKENBERG, 1875, pl. 1, figs. 3a–c.
Type locality: River Indiga, Timan, U.S.S.R.

Description

Shell auriculate with trapezoidal to pentagonal outline. Pedicle valve gently to very strongly convex but rarely geniculate. Narrow, moderately deep sulcus separates rounded visceral humps. Ears arched on pedicle valve and flat on brachial valve but vary from short and broad to long and narrow, with cardinal extremities rounded or pointed. Visceral disc of brachial valve flat, with low, narrow, median fold; anterior border geniculated. Both valves have fine granular sculpture often obscured by loss of outer shell layer or by silicification. Coarse irregular costae often present on anterior slope. Spines large, halteroid; on pedicle valve limited to visceral humps where they form 1–3, rarely more, longitudinal rows; on brachial valve forming cardinal row of 4–9 on each side of umbo, increasing in thickness and ? length distally and running posteriorly at about 30° to sagittal plane of shell; and group on ears, not always present, numbering up to seven, of similar size to distal cardinal spines and running anterolaterally at about 45° to hinge line.

Interior of pedicle valve has broad adductor muscle platform in posterior half, merging posteriorly with thickened umbo, with vertical sides, and terminating abruptly at rounded anterior. Adductor muscle impressions elongate and dendritic. Divaricator muscle impressions large, rounded triangular, anterior part longitudinally ridged. Brachial valve thickened and commonly well-preserved. Interior with narrow median septum, extending to anterior border of flat visceral disc where it is usually strongly developed. Cardinal process trilobed, on broad base, bilobed anteriorly, lobes separated by median depression, median lobe forked; posterior surface of all lobes transversely ridged. Adductor muscle impressions triangular, dendritic, lying posteriorly, with raised lateral and anterior borders, and sloping towards base of cardinal process. Lateral ridges broad, short, diverging 10°–15° from hinge line. Brachial ridges subcircular. Surface smooth posteriorly, ears finely pustulate; endospines scattered anteriorly, coarsening along geniculation and on trail.

Discussion

TOULA described this species in 1875 as *Productus horridus* var. *granuliferus*. Whether he has priority over STUCKENBERG is not known as neither paper gives the month of publication. However, STUCKENBERG's description and figures are more adequate than those of TOULA and it seems justifiable to use STUCKENBERG's name. STUCKENBERG's description is fairly complete. He strongly suggested that cardinal spines were present on the pedicle valve and his figures show spine bases in this region. However, in one Timan specimen I have seen and also in specimens from Spitsbergen, opposite each dorsal cardinal spine there is a depression in the thin cardinal border of the pedicle valve. Between these depressions the relatively raised shell simulates spine bases, for which, I assume, STUCKENBERG mistook it.

The variation in form that is exhibited by *H. timanica* has given rise to much discussion on the relationship of the arctic specimens to the Russian ones. The species is abundant in the Spirifer Limestone of Svalbard and there exhibits a range of forms which encompasses varieties, sub-species, and even species described from other areas. FREDERICKS (1934) described this species from the Kanin Peninsula. He thought presumably that the granular sculpture formed the bases of fine spines lying tangential to the surface and put it into the genus *Ruthenia* (= *Waagenoconcha*). His three sub-species, *R. granulifera typica*, *R. granulifera gibbosa*, and *R. granulifera spitzbergensis* parallel respectively STEPANOV's (1937 a) *Horridonia borealis granulifera, H. borealis borealis,* and *H. borealis granulifera* ab. *auriculata* from Spitsbergen. STEPANOV's sub-species are also more or less equivalent to DUNBAR's (1955) *Sowerbina rudis* (= *borealis*) and *S. maynci* (= *granulifera*) from east Greenland.

None of these forms were considered by their authors to be conspecific with *H. timanica.* FREDERICKS identified them with TOULA's *granuliferus*; STEPANOV with *Productus sulcatus* var *borealis* HAUGHTON 1858, which he thought intermediate between *H. timanica* and *H. horrida.* HAUGHTON's species is represented by two syntypes which were lent to me from the National Museum of Ireland The larger specimen is identical with a specimen of *H. horrida* (S. M. G 832) from the Magnesian Limestone of Yorkshire. The smaller specimen is a *Liosotella* probably conspecific with *L. spitzbergiana* DUNBAR, not TOULA.

FREBOLD (1942, p. 14) discussed *H. timanica* at length. He concluded (p. 21, translated from the German):

P. (*Horridonia*) *timanicus* has a wide distribution in the arctic. This agrees with the views of TSCHERNYSCHEW, WIMAN and others. It does not seem permissable to me to include these arctic *timanici* as a variety of *P. borealis*, namely var. *granulifera*, as STEPANOV would have it. If one would separate the arctic *timanici* from the Russian *timanicus* by a very narrow conception of species, one must admit that they are closer to the Russian *timanicus* than to *P. borealis*. Thus they would be included rather as a variety of the Russian *timanicus* than as *P. borealis*.

Productus (*Horridonia*) *borealis borealis* must be recognised as a species in its own right. Typical examples are described particularly by LICHAREW in his new work on Novaya Zemlya and by STEPANOV from Spitsbergen. The fact that neither LICHAREW (from Novaya Zemlya) nor I (from east Greenland) found *P. timanicus* and *P. borealis* occurring together at one and the same horizon, suggests that they are of somewhat different ages. *P. timanicus* and *borealis* are related to one another as is repeatedly brought to notice. Both these forms are also again closely related to the

Upper Permian *Productus* (*Horridonia*) *horridus,* likewise a fact noticed many times. It seems doubtful to me that HAUGHTON's badly preserved *P. sulcaltus* var. *borealis* can be truly considered as a holotype for *P. borealis*.

It must be pointed out that FREBOLD had not seen HAUGHTON's specimens; they are in fact well preserved The specimens from Novaya Zemlya called *P.* (*Horridonia*) *borealis* by LICHAREW and EINOR (1939) to which FREBOLD refers are, from their illustrations, probably conspecific with *H. horrida* and thus also with *P. borealis* HAUGHTON. FREBOLD compares these with the specimens from Spitsbergen called *H. borealis borealis* by STEPANOV which are connected by transitional forms with *H. borealis granulifera* STEPANOV. The latter FREBOLD acknowledges as *H. timanica*.

I conclude that two variable species are present One is *H. timanica* which varies in its convexity and the size of the ears. The other is *P. borealis* = *H. horrida* (J. SOWERBY) which has cardinal spines on the pedicle valve as well as on the brachial one. Only *H. timanica,* in all its forms, occurs in Svalbard.

Occurrence

Horridonia timanica is one of the most abundant species in the Spirifer Limestone of Svalbard. Specimens in the Sedgwick Museum are from Tempelfjorden, Bjonadalen (E 17828), Bjonahamna (E 17832–38), Templet (E 17817–19, E 17421, E 17427); Bünsow Land, Pyefjellet (E 17820), Gipshuken (E 17517, E 17524), Tyrellfjellet (E 17608, E 17650); Billefjorden, Skansbukta (E 17829); Nordfjorden, Kapp Wijk (E 17830–1).

In Ny Friesland it was collected from the Lower Brachiopod Chert of Chydeniusbreen, Mertonberget (E 17821–26) and Oslobreen, Komarovfjellet (E 17827); in Bjørnøya from Miseryfjellet (E 18346), Lakselva (E 17861), and Lundenæringane (E 17857–60).

TSCHERNYSCHEW (1902) recorded *H. timanica* from the Lower Permian of the Ural and the Timan, FREDERICKS (1934) from the Permian of the Kanin Peninsula, and SOLOMINA (1960) from the Talatinsk Series of Pai Choi. It is common in the Permian of central east Greenland (FREBOLD 1931, DUNBAR 1955), and in Amdrups Land and Holms Land in north-east Greenland (GRÖNWALL 1917, FREBOLD 1950). In arctic Canada it has been described from Great Bear Cape, Ellesmere Island (TSCHERNYSCHEW and STEPANOV 1916), and from Cape Sheridan at the northern tip of Ellesmere Island (WHITFIELD 1908).

Horridonia geniculata sp. nov.
Plate 10, figs. 5–7

Holotype: S. M. E 17978.
Type locality: Cora Limestone, west side of Ymerdalen, Bjørnøya.

Description

Horridonia with strongly geniculate pedicle valve. Outline rectangular, greatest width lying at hinge line. Cardinal extremities pointed. Visceral area posterior to geniculation, moderately convex, triangular in outline and separated from flattened

ears by steep lateral slopes. Umbo broad, protruding slightly posterior to hinge line. Narrow median sulcus originating 5 mm from umbo and running to anterior margin, separating rounded visceral humps. Brachial valve and internal characters unknown. Shell surface smooth with fine growth lirae and about six low, rounded, rugae on posterior visceral area and flanks. Single row of large cardinal spine bases, and scattered spine bases on anterior slope.

Discussion

This species is known only from the holotype and one other specimen (Br. 102266) in the Riksmuseum, Stockholm, a pedicle valve from the type locality.

It differs from *H. horrida* in the geniculated pedicle valve and the presence of rugae. *Levitusia* MUIR-WOOD and COOPER (1960, p. 295) has a different spine distribution and a thicker pedicle valve.

Family Linoproductidae STEHLI, 1954
Subfamily Linoproductinae STEHLI, 1954

Genus *Linoproductus* CHAO, 1927

1927 *Linoproductus* CHAO, p. 25, 128.
1928 *Cora* FREDERICKS, p. 781, 790.
1928 *Euproductus* WHITEHOUSE, p. 281.
1960 *Linoproductus* MUIR-WOOD and COOPER, p. 296.
Genotype: *Productus cora* D'ORBIGNY.

Linoproductus dorotheevi (FREDERICKS).
Plate 10, figs. 8–9; plate 11, figs. 1–5

1902 *Productus cora* TSCHERNYSCHEW (not D'ORBIGNY), p. 621, pl. 33, figs. 2–3, pl. 35, fig. 1, pl. 54, figs. 1–5.
1902 *Productus lineatus* TSCHERNYSCHEW (not WAAGEN), p. 625, pl. 48, fig. 4.
1914 *Productus lineatus* WIMAN (not WAAGEN), p. 70, pl. 13, figs. 14–15.
1932 b *Cora dorotheevi* FREDERICKS, p. 55, footnote.
1937 a *Productus* (*Linoproductus*) cf. *cora* STEPANOV, p. 130, pl. 2, fig. 10.
1952 *Linoproductus lineatus* WANG (not WAAGEN), p. 347.
1958 *Productus cora* FORBES (not D'ORBIGNY), p. 473.
1958 *Productus* (*Linoproductus*) *lineatus* FORBES (not Waagen), p. 473.

Description

Large concavo-convex shells, elongate, with rounded quadrate outline. Pedicle valve convex with broad, low umbo, steep flanks, and flattened venter produced anteriorly into trail, sometimes recurved. Some specimens with shallow sulcus, disappearing on trail. Ears large, flattened and triangular in outline. Ears and trail frequently damaged giving shell sub-circular outline. Brachial valve moderately concave, geniculated into short trail. Sculpture of costae, 14–16 in 10 mm on visceral disc and about 12 in 10 mm on trail, equal to or narrower than intercostal sulci on posterior part of valves, broader than intercostal sulci on anterior slope and trail where they become sinous and coalesce. Few broad rugae on ears and flanks of pedicle valve, 6–7 crossing visceral disc of brachial valve. Spine

bases large, up to 2 mm in diameter, forming cardinal row and scattered on anterior slope and trail of pedicle valve, where they disrupt costae.

Interior of pedicle valve not seen. Interior of brachial valve with massive, broad-based trilobed cardinal process, and prominent median septum in posterior part of valve, dividing elongate-oval dendritic adductor muscle impressions. Lateral ridges diverging from hinge line, bounded anteriorly by deep groove. Brachial ridges elongate. Anterior part of visceral disc and trail pustulate.

Discussion

This large species appears to be conspecific with specimens figured by TSCHERNYSCHEW as *P. cora* and *P. lineatus*. There is some variation in the amount of flattening of the venter and the presence or absence of a shallow sulcus. *Linoproductus cora*, as represented by a plaster cast of the specimen figured by D'ORBIGNY (1842, pl. 5, figs. 8–10), is more convex, less elongated, has finer costae, and more numerous spines than any Spitsbergen form. From the literature *L. lineatus* (WAAGEN) appears to be a smaller species than that described here, and to have a more regular costation. FREDERICKS considered *P. lineatus* TSCHERNYSCHEW to be distinct from WAAGEN's species and renamed it *dorotheevi* in which species I include the present specimens. *L. neffedievi* VERNEUIL is another similar species. It is poorly known; the specimen figured by VERNEUIL has more regular costae than *L. dorotheevi* and there are no spine bases on the pedicle valve anterior slope. The form which occurs in the Cora Limestone of Bjørnøya, which was identified with *L. cora* by ANDERSSON (1900, p. 256) probably belongs here.

Occurrence

L. dorotheevi occurs in Spitsbergen in the Cyathophyllum Limestone, particularly in the Upper Wordiekammen Limestone of Bünsow Land, Teltfjellet (S. M. E 17074–5), Tyrellfjellet (S. M. E 17320–2, E 17355, E 18695, E 18270), Gipsvika (S. M. E 17378–83), Brisingefjellet (S. M. E 17330–5), Gerardfjella (S. M. E 18376); and in the Upper Gypsiferous Series, Templet (S. M. E 17391).

Linoproductus lutkewitschi STEPANOV

1936 *Productus lutkewitschi* STEPANOV, p. 127, pl. 1, figs. 5a–c.
1937 a *Linoproductus lutkewitschi* STEPANOV, p. 135, pl. 3, figs. 1 a–c.
1937 *Linoproductus cora planus* FREBOLD, (not MILORADOVICH), p. 24, pl. 9, figs. 5–7.

Linoproductus lutkewitschi is doubtfully represented in the Cambridge Spitsbergen collections by a single pedicle valve (S. M. E 18751) from the Middle Brachiopod Chert, Gipshuken. STEPANOV based this species on a single pedicle valve from the Brachiopod Chert of Kongressdalen. FREBOLD (1937, p. 89) referred *L. lutkewitschi* STEP. to *L. cora planus* (MILORADOVICH), described from Novaya Zemlya. In 1939 LICHAREW and EINOR figured further specimens from Novaya Zemlya and they pointed out that *Productus planus* MILORADOVICH was a junior homonym and used STEPANOV's name for the species.

It is doubtful whether *planus* MILORADOVICH is conspecific with *lutkewitschi* STEPANOV. The pedicle valves from Novaya Zemlya figured by LICHAREW and EINOR (1939, pl. 5, figs. 2–5) are more flattened and have larger ears than *lutkewitschi*.

Linoproductus sp. A
Plate 11, fig. 6

Description

Concavo-convex shell, rounded quadrate in outline and extended slightly transversely. Hinge line equal to greatest width. Pedicle valve with gently convex visceral disc, slightly flattened on venter, geniculated anteriorly, flanks sloping gently to large, flattened triangular ears. Umbo broad, pointed, slightly inflated. Brachial valve gently concave, geniculated anteriorly. Costae fine, about 25 in 10 mm, 3–4 rugae on ears. Spines form cardinal row but rare on rest of valve.

Discussion

This form differs from *L. dorotheevi* in its finer costation, less steep flanks and lack of spines on the anterior slope and trail. It is represented by two specimens from the Passage Beds of Minkinfjellet (S. M. E 17209–10) and one from the scree *ex* Lower Wordiekammen Limestone, Wordiekammen (S. M. E 18114). Another pedicle valve (S. M. E 17987) from the Ambigua Limestone, north of Kapp Kåre, Bjørnøya may belong here.

Linoproductus? sp. B.
Plate 11, figs. 7–8

Six well-preserved external moulds of a small linoproductid (S. M. E 18765–70) were collected from the transition beds between the Billefjorden Sandstone and the Lower Gypsiferous Series on Odellfjellet.

Genus *Ovatia* MUIR-WOOD and COOPER, 1960, p. 311.
Genotype: *Ovatia elongata* MUIR-WOOD and COOPER.

Ovatia cf. *simensis* (TSCHERNYSCHEW).
Plate 11, figs. 9–10

cf. 1902 *Productus simensis* TSCHERNYSCHEW, p. 626, pl. 35, fig. 7, pl. 55, figs. 2–5.
?1916 *Productus simensis* TSCHERNYSCHEW and STEPANOV, p. 59, pl. 8, fig. 4.
1927 *Linoproductus simensis* CHAO, p. 137, pl. 14, figs. 6–8.
?1952 *Linoproductus simensis* SARYCHEVA and SOKOLSKAYA, p. 114, pl. 20, No. 144.

Description

Outline elongate oval. Pedicle valve strongly convex with irregular curvature, flanks steep, venter flattened, sulcus absent. Umbo narrow, slightly inflated. Hinge line slightly less than greatest width which lies anteriorly. Ears small and flattened. Brachial valve concave, geniculated into trail. Sculpture of fine costae, 20–24 in 10 m, increasing by intercalation, and becoming sinuous on trail.

Four or five rugae on ears, the more posterior ones crossing visceral disc of pedicle valve; more numerous rugae on brachial valve visceral disc. Spines small, along hinge line, on ears, and sparsely scattered on visceral disc and trail of pedicle valve. Shell thin and sculpture preserved on internal moulds. Internal characters not seen.

Discussion

This species resembles *P. simensis* TSCHERNYSCHEW in the form and sculpture of the pedicle valve but there is no sign of the keeled trail shown on TSCHERNYSCHEW's plate 37, fig. 7. *Productus simensis* was not explicitly included in the genus *Ovatia* by MUIR-WOOD and COOPER. However the Spitsbergen form has the characters of this genus. *O.* cf. *simensis* differs from *O. tenuistriatus* (VERNEUIL) in the less incurved umbo and less regular curvature of the valves. The form figured by TSCHERNYSCHEW and STEPANOV has a broader visceral disc and coarser costation and may belong to *Linoproductus*. CHAO's description and figures closely resemble the Spitsbergen specimens but those figured by SARYCHEVA and SOKOLSKAYA have a more equidimensional outline.

Occurrence

O. cf. *simensis* was collected from Billefjorden from the Lower Gypsiferous Series, Ebbadalen (S. M. E 17904–5) and from the Passage Beds at Rudmosepynten (S. M. E 18111) and on Sfinksen (S.M. E 18134). There are also three unlabelled specimens from the Tårnkanten Sandstone.

TSCHERNYSCHEW recorded *O. simensis* from the "Schwagerinakalk" of the Urals. In the Moscow Basin however, SARYCHEVA recorded it from the Moskovian and Upper Carboniferous.

Genus *Cancrinella* FREDERICKS, 1928

1928 *Cancrinella* FREDERICKS, p. 791.
1937 *Cancrinella* SARYCHEVA, p. 110.
1955 *Cancrinella* DUNBAR, p. 70.
1960 *Cancrinella* MUIR-WOOD and COOPER, p. 301.
Genotype: *Productus cancrini* DE KONINCK.

Discussion

This genus was proposed by FREDERICKS to include productids with "ornamentation of striae and thin spines". It was discussed in more detail by SARYCHEVA (1937) and emended by MUIR-WOOD and COOPER (1960).

The productids now included in this genus form two groups within which it is often difficult to define species. Most forms are small and the details of their fine sculpture are difficult to illustrate. Using early descriptions and figures of *C. villiersi* (D'ORBIGNY 1842), *C. cancrini* (VERNEUIL 1845) and *C. koninckianus* (KEYSERLING 1846) it is almost impossible to define these as separate species. However, when further works and specimens are examined a variety of forms becomes apparent.

The species of *Cancrinella* from Spitsbergen have usually been referred to *cancrini* or *koninckianus*, to which species they appear to be closely related. However, the delimitations of these two species is far from clear and many authors have confused them or treated them as synonymous. The status of *Cancrinella koninckiana* is doubtful.

This species was first mentioned by VERNEUIL (1845, p 274) He applied the name to a specimen from the Viséan of Belgium figured by DE KONINCK (1844, p. 179, pl. 9, figs. 3 a–b) as *Productus cancrini* and also to other specimens from the Upper Carboniferous or Permian rocks exposed by the river Soiva (63° N, 55° 30′ E). According to VERNEUIL *P. koninckiana* had a more concave brachial valve than *P. cancrini* and also shorter spine bases, carried on a single lira. DE KONINCK's specimen was later (DE KONINCK 1847, p. 103) reidentified as *Productus spinulosus* SOW. He also treated the Russian specimens of *P. koninckiana* as conspecific with *P. spinulosus* which, now the genotype of the *Krotovia*, is quite distinct from *Cancrinella*.

The Russian *P. koninckianus* as distinct from DE KONINCK's Viséan species, was fully described and figured by KEYSERLING (1846, p. 203, pl. 4, figs. 4 a–c). He recognized this species to be very similar to *P. cancrini* VERN. but he regarded it as distinct. According to KEYSERLING, *P. koninckianus* had a greater curvature of the pedicle valve and a more inflated umbo than *P. cancrini*. The brachial valve was regularly and deeply concave and the spine bases arose from a single lira. *P. cancrini* had a geniculate brachial valve; the ears were small but distinct and crowded with erect spines. Two lirae usually coalesced to form an elongated spine base.

These distinctions have been criticised. According to FREBOLD (1932, p. 21), TSCHERNYSCHEW (1885) considered the only reliable difference to be in the form of the brachial valve, geniculate in *cancrini* and regularly concave in *koninckianus*. MILORADOVICH (1935, p. 131) questioned this character also and showed that the form of the brachial valve was continuously variable.

Specimens from Spitsbergen may be divided into four well-defined forms, all of which could be included in the *cancrini-koninckiana* group of *Cancrinella*. However none of these are strictly comparable with the illustrations of *P. cancrini* given by VERNEUIL (1845, pl. 16, figs. 8 a–c, pl. 18, figs. 7 a–b) and, in order not to add to the existing confusion surrounding *koninckiana*, I have treated them below as four new species.

Cancrinella singletoni sp. nov.
Plate 12, figs. 1–7

1902 *Productus koninckı* TSCHERNYSCHEW (not VERNEUIL), p. 629, pl. 34, figs. 2–3.

?1911 *Productus koninckianus* NETSCHAJEW, (not VERNEUIL), p. 137, pl. 3, figs. 7–10, 12, pl. 4, fig. 1.

1952 *Cancrinella cancriniformis* WANG, (not TSCHERNYSCHEW), p. 347.

1958 *Productus koninckı* FORBES, (not VERNEUIL), part, p. 473.

Type data

Holotype: S. M. E 18232.

Paratypes: S. M. E 18230, E 18239–40, E 18243, E 18250, E 18692–4.

Type locality: Upper Wordiekammen Limestone, exposed in low cliffs north-west of the river mouth, Gipsvika, Bünsow Land, Spitsbergen.

Description

Pedicle valve strongly and regularly convex with elongated sub-triangular outline. Umbo narrow and inflated; umbonal angle about 85°. In cross section venter broadly rounded and lateral areas vertical. Hinge line short, produced into small flattened ears, sharply separated from umbonal slope. Greatest width near anterior border. Brachial valve hemispherical to geniculate. Long trail giving gerontic shells very elongated form.

Sculpture of typical cancrinellid type. Costae low and rounded, broader than intercostal sulci, numbering about 20 in 10 mm, normally straight and constant in width but may become irregular and sinous on trail. Spine ridges swollen, formed from one, two, or three costae. Spines suberect. Three or four rugae sometimes developed on ears and flanks of both valves and may extend partly across the visceral disc of brachial valve. Shell very thin and internal moulds show sculpture clearly. Brachial valve without spine bases but with dimples opposite spine bases of pedicle valve. Thus sculpture visible on external mould of brachial valve resembles that on internal mould of pedicle valve. Internal characters unknown.

This species is named in honour of Dr. O. P. SINGLETON, whose collecting provided much of the material on which this work is based.

Occurrence

C. singletoni is common in the Upper Wordiekammen Limestone of Spitsbergen. It is not found in the Brachiopod Chert. Upper Wordiekammen Limestone, Campbellryggen (S. M. E 17092), Brisingefjellet (S. M. E 17336–40), Tyrellfjellet (S. M. E 18692–4), Gipsvika (S. M. E 17384–5, E 18230–50), ?equivalent of Upper Wordiekammen Limestone, Rejmyrefjellet (S. M. E 18818–25), Mertonberget (S. M. E 18000–2), Cepheusfjellet (S. M. E 18144–5); Upper Gypsiferous Series, Tyrellfjellet (S. M. E 18675–9).

FREBOLD (1937, p. 32) records what is probably this species from the Upper Wordiekammen Limestone of Gangerolvfjella, Dickson Land and WIMAN (1914, p. 71) notes "*Productus konincki*" from the Cyathophyllum Limestone and Cora Limestone of Bjørnøya as well as from the Spirifer Limestone. Thus part of WIMAN's *P. konincki* probably belongs here.

Cancrinella spitsbergiana sp. nov.
Plate 12, figs. 8–12

?1845 *Productus punctatus* ROBERT, (not J. SOWERBY), pl. 19, figs. H, I, M.
1850 *Productus cancrini* DE KONINCK, (not DE KONINCK, 1842), p. 635, fig. 2.
1874 *Productus koninckianus* TOULA (not VERNEUIL) p. 16, pl. 2, fig. 4.
1875c *Productus cancrini* TOULA, (not DE KONINCK 1842), p. 251, pl. 8, fig. 7.
1914 *Productus konincki* WIMAN, (not VERNEUIL), p. 71, part.
1936 *Productus cancrini* STEPANOV, (not DE KONINCK 1842), p. 122, pl. 5, figs. 7–8.
1937a *Productus* (*Linoproductus*) *cancrini* STEPANOV, (not DE KONINCK 1842), p. 133, 178, pl. 3, figs. 4–6.
1937 *Productus* cf. *konincki* FREBOLD, p. 34, pl. 10, figs. 12–13.
1958 *Productus konincki* FORBES, (not VERNEUIL), part, p. 474, 475.

Type data

Holotype: S. M. E 18684.

Paratypes: S. M. E 17432, E 17435, E 17438, E 18020–1, E 18024, E 18192–201, E 18486.

Type locality: Spirifer Limestone, Tyrellfjellet, Bünsow Land, Spitsbergen.

Description

Form similar to that of *Cancrinella singletoni* sp. nov., but pedicle valve with flattened venter, varying in width, usually broad. Outline triangular; greatest width near anterior border. Brachial valve geniculated. Sculpture finer, costae narrower, more sharply rounded and less regular, numbering about 25 in 10 mm. Internal moulds show sculpture less clearly and usually as sharp grooves. Spine ridges and spines similar to those of last species but more numerous, especially on flanks, where spine bases are circular, indicating erect spines.

Discussion

Most of the previously described *Cancrinella* from Spitsbergen belong to this species which is probably closely related to the previous one. Individual specimens, if sufficiently well preserved, can be assigned easily either to *C. singletoni* or *C. spitsbergiana* and intermediate forms have not been recognized. The two species occur at different stratigraphic levels.

Cancrinella spitsbergiana is similar to *C. pyramidalis* (NETSCHAJEW) but in the latter species the ears are larger and the greatest width of the shell lies at or near the hinge line. *C. bolchovitinovae* (MIRCHINK) as figured by DUNBAR (1955, pl. 3, figs. 9–20) differs from *C. spitsbergiana* in having sub-parallel flanks and more numerous spines. *C. germanica* (FREBOLD) has large welt-like spine ridges.

Occurrence

Cancrinella spitsbergiana is common in the Spirifer Limestone of Svalbard and also occurs in the Upper Gypsiferous Series of Spitsbergen.

Upper Gypsiferous Series Bünsow Land, Templet (S. M. E 17392–7), Wardropfjellet (S. M. E 17407–10), Burn Murdochbreen (S. M. E 18192–201). Spirifer Limestone, Chydeniusbreen, Mertonberget (S. M. E 18018–24); Oslobreen

station G 859 (S. M. E 18155); Bünsow Land, Usherfjellet (S. M. E 18870), Tyrellfjellet (S. M. E 18684–5), Gipshuken (S. M. E 17525–30), Templet (S. M. E 17428–9, E 17431–5, E 17437–43, E 17463, E 18667), Bjonahamna (S. M. E 18486–9), Barkowfjellet (S. M. E 18331).

Cancrinella tenuissima sp. nov.
Plate 12, figs. 13–15

1937 *Productus* aff. *konincki* and *cancrini germanicus* FREBOLD, p. 34, pl. 10, figs. 14–15.

Type data

Holotype: S. M. E 18383.
Paratype: S. M. E 18384.
Type locality: Brachiopod Chert, Komarovfjellet, Oslobreen, Ny Friesland, Spitsbergen.

Description

Pedicle valve hemispherical, slightly elongated, with narrow umbo. Sculpture of fine capillae, about 35 in 10 mm, gently rounded in cross section and broader than sulci between them. Swollen elongated spine bases formed from 4–5 capillae. Larger circular spine bases abundant on trail and flanks. Brachial valve and internal characters not known.

A silicified specimen with the spines in place, in the Mineralogical Museum, Copenhagen, resembles this species. It was obtained from northeast Greenland but no details of the locality are given.

Occurrence

The holotype and one paratype are the only specimens in the Sedgwick Museum. FREBOLD recorded this species from the north-east corner of Hornsund and from the Brachiopod Chert of Festningen, Isfjorden.

Cancrinella crassa sp. nov.
Plate 12, figs. 16–21

Type data

Holotype: S. M. E 18389.
Paratypes: S. M. E 18390–8.
Type locality: Upper Cyathophyllum Limestone, Komarovfjellet, Oslobreen, Ny Friesland, Spitsbergen.

Description

Size and form of valves similar to those of *C. singletoni* sp. nov. but sculpture coarser. Costae rounded in cross section, not coalescent, and numbering about 16 in 10 mm. Spines arise each from single costa, spine base increasing height of costa but not its width. Ears of brachial valve larger than in *C. singletoni* and visceral disc crossed by about 10 prominent rugae forming reticulate pattern with costae. Shell thin and sculpture shows clearly on internal moulds.

Discussion

This species may be conspecific with *C. dieneri* (NETSCHAJEW 1911, p. 138, pl. 3, fig. 13, pl. 4, fig. 2). NETSCHAJEW described *C. dieneri* as very close to *C. koninckiana* and differing from it chiefly in the flattening of the lower border of the pedicle valve. Unfortunately, he does not describe the sculpture in detail.

Occurrence

This species has been found only at its type locality (S. M. E 18389–412).

Genus *Anidanthus* WHITEHOUSE, 1928

1928 *Anidanthus* WHITEHOUSE, p. 282.
:1934 *Pseudomarginifera* STEPANOV, p. 56.
1950 *Anidanthus* HILL, p. 9.
1960 *Anidanthus* MUIR-WOOD and COOPER, p. 299.

Genotype: *Linoproductus springsurensis* BOOKER. This genus was discussed by MUIR-WOOD and COOPER 1960. The inadequately defined genus *Pseudomarginifera* STEPANOV, with *Productus ussuricus* FREDERICKS as genotype, is probably synonymous with *Anidanthus*. Both genera are characterized by the lamellar sculpture of the brachial velve. STEPANOV included *Productus aagardi* TOULA in *Pseudomarginifera*.

Anidanthus aagardi (TOULA)
Plate 12, figs. 22–26

1875c *Productus aagardi* TOULA, p. 235, pl. 7, figs. 2a–c.
1914 *Productus aagardi* WIMAN, p. 70.
1937 *Productus* (*Linoproductus*) *aagardi* FREBOLD, p. 30.
1937 *Productus* (*Linoproductus*) aff. *waagenianus* FREBOLD, p. 31, pl. 10, figs. 7, 10, 11.
1937a *Productus* (*Linoproductus*) *aagardi* STEPANOV, p. 177, pl. 3, figs. 3, 10, 11.
1939 *Productus* (*Productus*) *aagardi* LICHAREW and EINOR, p. 205, pl. 6, figs. 3–5.

Type data

TOULA's single figured specimen must be taken as the holotype.
Type locality: Akseløya, Bellsund, Spitsbergen.

Description

Concavo-convex shells, rectangular to broadly triangular in outline, width greater than length and greatest width anterior to hinge line. Pedicle valve regularly and moderately convex, venter flattened, sulcus absent. Umbo narrow, inflated, with sharply pointed tip scarcely overarching hinge line. Ears small and flattened. Brachial valve (1 specimen) distorted, appearing strongly geniculated. Visceral disc concave and clearly delimited from flat ears.

Sculpture of rounded costae, broadening and flattening on anterior slope where they become irregular, their number varying from 9–14 in 5 mm on anterior border. Two or three rugae on flanks of some pedicle valves. Brachial valve with concentric lamellae representing successive broken off trails. Spine bases form cardinal row and are scattered in small numbers on anterior slope of pedicle valve.

Interior of pedicle valve shows broad, low, adductor muscle platform, with elongate triangular outline, posteriorly sunken below interior surface of thickened umbonal area. Interior of brachial valve not seen.

Discussion

This species shows a considerable variation. It has generally been poorly described and, from the literature, may easily be confused with other small linoproductids, so that it is difficult to assess its distribution outside Spitsbergen. TOULA's original specimen, a pedicle valve, is now lost. It was re-figured by LICHAREW and EINOR (1939, pl. 6, fig. 5). The form and sculpture of this valve agrees with that of the present specimens. The specimens figured by TSCHERNYSCHEW (1902, pl. 56, figs. 1–3) show a greatly incurved pedicle umbo and large ears.

WIMAN (1914) did not figure *A. aagardi*. His description may have included forms referable to *Megousia harlandi* sp. nov. or *Megousia weyprechti* (TOULA). He remarked on the variability of the sulcus, described the brachial valve as geniculate, and that (p. 70) "In connection with the rugae, growth lines originate from the freely projecting shell edge, which give the shell a laminated appearance." STEPANOV (1934, p. 57) used this character in his diagnosis of a new subgenus *Pseudomarginifera* but in 1937(a) he referred *aagardi* to *Linoproductus*.

Occurrence

A. aagardi occurs in the Brachiopod Chert of Isfjorden and Bellsund, and also from Ny Friesland. LICHAREW and EINOR recorded it from Abrossimov Bay on the east coast of the South Island of Novaya Zemlya. The specimens described here are from the Brachiopod Chert, of Trygghamna (P. M. O. A 9862, A 9869–70), Rejmyrefjellet (P. M. O. A 26217, A 26215–18(1), A 26220), Reinodden (P. M. O. A 28327, A 28330(2)), Polarisbreen, Cepheusfjellet (S. M. E 18039–46, E 18055–8), Rundodden (? S. M. E 18283–92), Gipshuken (S. M. E 18801–5); and from moraine, Brucebreen (S. M. E 18377–80).

Genus *Megousia* MUIR-WOOD and COOPER, 1960, p. 309

Genotype: *Megousia auriculata* MUIR-WOOD and COOPER.

Megousia weyprechti (TOULA)

Plate 12, figs. 27–29, Plate 13, figs. 1–6

1874 *Productus weyprechti* TOULA, p. 279, part, pl. 5, figs. 2–3 only.
1875c *Productus weyprechti* TOULA, part, pl. 7, fig. 8d only (given incorrectly as fig. 7 in the legend).
?1902 *Productus multistriatus* MEEK var. TSCHERNYSCHEW, p. 607, pl. 32, fig. 2a–d.
1914 *Productus weyprechti* WIMAN, p. 64, part, pl. 13, figs. 2–6 only.
1916 *Productus aagardi* TSCHERNYSCHEW and STEPANOV, p. 58, pl. 8, fig. 3.
1937 *Productus* (*Linoproductus?*) *weyprechti* FREBOLD, p. 27, pl. 9, fig. 4.
1937 *Productus* (*Linoproductus?*) *svalbardensis* FREBOLD, p. 29, pl. 5, figs. 1–5.
1958 *Productus* (*Linoproductus?*) *svalbardensis* FORBES, p. 475.

Type data

Lectotype (here selected): the more complete of the two specimens figured by TOULA 1874, pl. 5, figs. 2a–b. This specimen is preserved in contact with the second specimen in the Naturhistorisches Museum, Vienna.

Type locality: Sørkappøya, Spitsbergen.

Description

Outline sub-quadrate to pentagonal. Pedicle valve strongly convex with broad umbo. Pronounced median sulcus, originating about 5 mm anterior to umbo and remaining constant in width. Hinge line forming greatest width, extended to form long, slightly arched ears, recurved anteriorly. Flanks steep. In longitudinal profile, curvature of pedicle valve often flattened over visceral disc, giving it slightly geniculate appearance. Brachial valve sharply geniculate with flat visceral disc and short trail. Ears flat, large (similar in area to visceral disc). Valves sculptured with fine, regular costae, increasing by division and intercalation, radiating on ears and normally numbering 12–13 in 5 mm but specimens preserved in coarse sandstone have only eight costae in 5 mm. Low rugae sometimes present on pedicle valve flanks and ears. Brachial valve with overlapping concentric lamellae. Small spine bases along hinge line of pedicle valve but no evidence of spines on rest of shell.

Interior of pedicle valve shown by internal moulds. Umbonal area thickened and smooth, continuous with parallel-sided adductor muscle platform which extends anteriorly as median fold. Adductor muscle impressions narrow, dendritic, situated posteriorly. Divaricator muscle impressions rectangular in outline, slightly longer than broad, longitudinally ridged, lining visceral hollows which have steep posterior slope separating them sharply from umbonal region. Shell of anterior part of visceral disc, ears and trail, thin; sculpture visible on internal mould.

Interior of brachial valve with cardinal process divided into two lobes by deep cleft, each lobe again divided posteriorly but continuous anteriorly with broad septum. Septum narrows to knife edge in centre of valve and is absent on anterior part of visceral disc. Lateral ridges low, diverging slightly from hinge line, increasing in height across base of ears and continuing as raised rim around anterior border of visceral disc. Adductor muscle impressions obscure, broadly triangular, ? dendritic. Brachial ridges elongate kidney-shaped and placed laterally.

The shell is thick but easily splits away from the internal mould and the ears are frequently damaged. The pedicle valve fractures easily along the line separating the visceral disc from the trail.

Discussion

TOULA originally figured two forms as *P. weyprechti*. These two forms are not conspecific and TOULA later restricted the name to the smaller form, given in the synonymy above. The lectotype is an internal mould of a pedicle valve. This specimen, which I have examined, shows that the adductor muscle impressions

lay on a fairly broad, high platform and that the large diductor impressions were separated from the umbonal area by an abrupt slope. The anterior margin of the diductor impressions is not precise and does not form a straight transverse line. On the anterior slope are impressions of fine plicae, numbering 13 in 5 mm. Some of the shell is present and is seen to have a prominent median sulcus. The internal mould of the umbo is blunt and broad. The anterior part of the mould is cracked transversely, which suggests that the brachial valve was geniculate.

FREBOLD's original specimens of *Linoproductus svalbardensis,* from Sørkappøya, include internal moulds of pedicle valves identical with the lectotype of *M. weyprechti,* and also complete shells. The latter are seen to be conspecific with the specimens in the Sedgwick Museum.

FREBOLD (1937, p. 29) distinguished *svalbardensis* from *weyprechti* by its stronger curvature and less transverse outline. However, FREBOLD's concept of *weyprechti* included the more transverse and less strongly convex shells, figured as *weyprechti* by TOULA (1875 c, pl. 6, figs. 2a–c), which are not conspecific with the lectotype described above. These shells belong to *Muirwoodia duplex* (WIMAN). *Productus* (*Thomasina*) *weyprechti* STEPANOV (1937, p. 128, pl. 2, figs. 8–9) and *Productus weyprechti* TSCHERNYSCHEW and STEPANOV (1916, p. 39, pl. 7, figs. 5–6) are also probably referable to *M. duplex*. The east Greenland shells figured as *weyprechti* by FREBOLD (1931, p. 23, pl. 3, figs. 3–6) have been shown to belong to a distinct species, *Muirwoodia groenlandica* (DUNBAR 1955, p. 103).

The genus *Megousia* was based on species recently described from the Leonardian and Word Formation of Texas and Mexico and its presence in Svalbard is of considerable interest. *M. weyprechti* can be distinguished from the American species by its larger size and strongly sulcate pedicle valve.

Occurrence

M. weyprechti is common in the Brachiopod Chert of Svalbard, and sometimes occurs in rock-forming quantities to the exclusion of other species.

Spirifer Limestone, Spitsbergen, Bjonadalen (S. M. E 18226), Bjonahamna (S. M. E 18540–1); Bjørnøya, Miseryfjellet (S. M. E 18073–6). Lower Brachiopod Chert, Sassenfjorden, Belvedere (S. M. E 18063–4, E 18450), west of Kapp Schoultz (S. M. E 18219). Middle Brachiopod Chert, Sassenfjorden, Rundodden (S. M. E 18084–90); Belvedere (S. M. E 18066–9, E 18662); Templet (S. M. E 17475–77, E 17480–3). Brachiopod Chert, Ny Friesland, Mertonberget (S. M. E 17992–3, E 18027–31); Cepheusfjellet (S. M. E 18047–52); Komarovfjellet (S. M. E 18382); station G 859 (S. M. E 18871); station G 860 (S. M. E 18176–85), Scree (S. M. E 18414–6); Sassendalen (specimen lost); Nordfjorden, south of Kapp Wijk (S. M. E 18316); Festningen, fossil horizon 12 (P. M. O. A 4543, A 4548, A 4551, A 5034–5); Sørkappøya (P. M. O. A 9743–4, A 10035–6, A 10038–9).

The incomplete pedicle valve (P. M. O. A 5486) figured by TSCHERNYSCHEW and STEPANOV (1916, pl. 8, fig. 3) as *Productus aagardi* closely resembles *M. weyprechti.* This specimen was collected from Great Bear Cape, Ellesmere Island and it represents the only reliable record of this species outside Svalbard.

Megousia kulikii? (FREDERICKS, 1915)
Plate 13, figs. 7–15

?1914 *Productus weyprechti* WIMAN (not TOULA, part, pl. 13, fig. 1.)
1936 *Productus kulikii* STEPANOV, p. 121, pl. 1, fig. 7.
1937a *Productus kulikii* STEPANOV, p. 132, pl. 3, fig. 2.
1958 *Productus weyprechti* FORBES (not TOULA), p. 475, part.
1960 *Linoproductus kulikii* SOLOMINA, p. 56, pl. 9, figs. 4–11.

Description

Visceral area sub-quadrate in outline; long narrow ears giving shell transverse appearance. Hinge line forming greatest width but ears usually damaged and form of cardinal extremities unknown. Pedicle valve strongly convex, spirally enrolled, extended anteriorly as trail. Umbo narrow, inflated and strongly enrolled. Venter broad, flattened, sometimes with shallow sulcus. Flanks steep, diverging anteriorly. Brachial valve with concave visceral disc and large, flat ears. Sculpture of high rounded costae, 6–8 in 5 mm, increasing by intercalation, radiating on ears. Visceral disc of brachial valve with concentric overlapping lamellae. Spine bases obscure.

Pedicle valve interior with thickened umbo, callous sometimes filling posterior part of valve. Adductor muscle platform low, broad and rectangular in outline. Adductor muscle impressions form two elongate strips. Divaricator muscle impressions sub-rectangular in outline, longitudinally ridged. Brachial valve interior with anteriorly bilobed cardinal process based on broad septum which narrows anteriorly and is highest at its termination near anterior border. Adductor muscle impressions rounded triangular in outline, raised on platform. Lateral ridges low, rounded, diverging slightly from hinge line, becoming higher and more angular across base of ears and continuing around anterior border of visceral disc as broad, low, rounded ridge. Brachial ridges kidney-shaped, placed laterally.

Discussion

STEPANOV (1936, 1937 a) figured a pedicle valve of this species as *Productus kulikii* FREDERICKS. The present material shows that it belongs to the genus *Megousia*. Since I have not seen FREDERICK's original description of *P. kulikii* which may not agree with *Megousia*, I have queried the specific identification. The specimens from the Vorkutsk Series of Pai Choi, described as *Linoproductus kulikii* by SOLOMINA (1960) appear conspecific with the Spitsbergen form.

M. kulikii? may be distinguished from *M. weyprechti* (TOULA) by its coarser sculpture, relatively broader venter and concave brachial valve.

Occurrence

Spirifer Limestone of Spitsbergen, Oslobreen, station G 859 (S. M. E 18151–2); Bünsow Land, Tyrellfjellet (S. M. E 17625–8); Gipshuken (S. M. E 17531–4, E 17575); Templet (S. M. E 18663); Bjonahamna (S. M. E 18620–8); Bjonadalen (S. M. E 18224); Gerardfjella (S. M. E 18357); Oscar II Land, Heimberget (X 679(5), S. M. E 18852–3).

Productus kulikii FREDERICKS was originally collected from the Lower Permian of the River Adzva, N. Ural.

Megousia harlandi sp. nov.
Plate 13, figs. 16–22

1958 *Productus weyprechti* FORBES, (not TOULA), p. 475, part.
1958 *Marginifera involuta* FORBES (not TSCHERNYSCHEW), p. 475.

Type data

Holotype: S. M. E 18555.
Paratypes: S. M. E 18544–5, E 18547, E 18549, E 18552–3.
Type locality: Spirifer Limestone, Bjonahamna, Tempelfjorden, Spitsbergen.

Description

Outline quadrate. Pedicle valve strongly and regularly convex with steep, sub-parallel flanks; umbo inflated and highly incurved. Median sulcus shallow, constant in width. Ears narrow, arched, incompletely preserved. Brachial valve has slightly concave visceral disc, geniculated into trail. Sculpture of fine angular costae, narrower than intercostal sulci, numbering 10–12 in 5 mm, radiating on ears. Concentric sculpture of brachial valve and spine bases obscure.

Pedicle valve interior has thickened umbonal region. Adductor muscle platform and muscle impressions similar to those of *M. kulikii?* (FREDS.). Brachial valve interior poorly preserved, resembling that of *M. kulikii?* but raised lateral and anterior border of visceral disc higher and more angular.

Discussion

This form has not previously been described as a distinct species and is named in honour of Mr. W. B. HARLAND who has done so much for Svalbard geology.

M. harlandi was probably confused by earlier authors with *M. weyprechti* (TOULA) and *Anidanthus aagardi* (TOULA). It is distinguished from *M. weyprechti* by its smaller size, less pronounced sulcus and concave brachial valve, and from *M. kulikii?* (FREDS.) by its fine, angular costae, sub-parallel flanks, relatively narrower venter and more angular raised border to the interior of the brachial valve visceral disc.

Occurrence

Common in the Spirifer Limestone at Bjonahamna (S. M. E 18542–65). It was also collected from the Spirifer Limestone of Templet (S. M. E 17417–9, E 17436, E 17444–6, E 18664–5) and Gipshuken (S. M. E 17501).

Subfamily Paucispiniferinae MUIR-WOOD and COOPER, 1960

Genus *Muirwoodia* LICHAREW, 1947

1947 *Muirwoodia* LICHAREW p. 187 (in Russian).
1955 *Muirwoodia* DUNBAR p. 103.
1960 *Muirwoodia* MUIR-WOOD and COOPER, p. 322.
Genotype: *Productus mammatus* KEYSERLING.

Muirwoodia mammata (KEYSERLING)
Plate 13, figs. 23–28

1846 *Productus mammatus* KEYSERLING, p. 206, pl. 4, figs. 5a–b.
1847 *Productus mammatus* DE KONINCK, p. 49, pl. 7, figs. 4a–c.
1902 *Productus mammatus* TSCHERNYSCHEW, p. 295, pl. 35, figs. 4–6.
1914 *Productus mammatus* WIMAN, p. 73.
1924 *Productus weyprechti* HOLTEDAHL (not TOULA), p. 35, pl. 22, fig. 6.
1927 *Linoproductus? mammatus* CHAO, p. 146, pl. 15, figs. 10–14.
1937 *Productus* (*Linoproductus?*) *mammatus* FREBOLD, p. 25.
1937a *Productus* (*Thomasina*) *mammatus* STEPANOV, p. 127, 177, pl. 2, figs. 5–7.
1960 *Muirwoodia mammatus* HARKER, p. 58, pl. 16, figs. 1–5.

Description

Outline rectangular, wider than long, greatest width at hinge line. Pedicle valve sharply geniculated across middle of visceral area, geniculation continuing to cardinal extremities and dividing valve into gently convex posterior and anterior areas. Flattened ears separated from visceral area by shallow depressions. Umbo low and broad, not protruding beyond hinge line. Narrow median sulcus originating about 5 mm from umbo, obscure posterior to geniculation but distinct on anterior slope and trail. Brachial valve has flat visceral disc, sharply geniculated into trail.

Both valves sculptured with low, rounded costae, about 10 in 5 mm on trail. Row of small cardinal spine bases; single, larger, halteroid spine bases at cardinal extremities and two or three on each side of anterior slope and trail. Internal mould of the pedicle valve shows broadly triangular diductor muscle impressions extending almost to geniculation. Interior of brachial valve not well preserved. Shell thin and all specimens more or less exfoliated.

Discussion

This rather distinctive productid may be confidently identified with KEYSERLING's species. The serrations along the cardinal border, described by HARKER (1960, p. 58) cannot be seen on the Spitsbergen specimens probably because they are not well enough preserved. The depth of the sulcus on the posterior part of the pedicle valve appears greater on Russian and Canadian specimens but this variation can be included within the limits of the species.

The specimen from the Tian-Shan described by KEIDEL (1906, p. 367, pl. 12, fig. 5) has a more inflated umbo and visceral disc than *M. mammata* and does not appear to be conspecific with this species. The specimens described by GRABAU (1936 a, p. 107, pl. 6, figs. 5–6, pl. 11, figs. 4–6) probably belong to two species, neither of them *mammata*. Those shown on GRABAU's plate 6 are larger forms, more like *M. duplex*, and the specimen figured on his plate 11 has an inflated pedicle visceral area and may be a *Marginifera*.

M. mammata is distinguished from most other *Muirwoodia* species by its smaller size and sharply geniculated pedicle valve. *Productus artiensis* TSCHERNYSCHEW is similar in size and form but has a broader sulcus and coarser costation. *M. transversa* COOPER (1957, p. 39) closely resembles *M. mammata* but has a deeper pedicle sulcus posterior to the geniculation.

Occurrence

In Spitsbergen *M. mammata* is found in the Brachiopod Chert of Isfjorden. The specimens described above were collected from Templet (S. M. E 17478–9); Belvedere (S. M. E 18451–2), and Skivefjellet (X 641(8), X 642(6), X 686(5), S. M. E 18854–6). In Russia it occurs in the Lower Permian of the Urals and in the Bolshezemelskaya Tundra. HOLTEDAHL has recorded it from "Cape Productus", north of Mashiginfjord on the west coast of the North Island of Novaya Zemlya, and Chao from the Permian of Jisu Honguer, Mongolia. In arctic Canada it occurs in the Assistance Formation of Grinnell Peninsula, Devon Island.

Muirwoodia duplex (WIMAN)

Plate 14, figs. 5–6

1845 *Productus martini* ROBERT, (not J. SOWERBY), pl. 19, figs. F, G.
1850 *Productus leplayi?* DE KONINCK (not VERNEUIL), p. 636, figs. 3a–b.
1860 *Productus mammatus?* SALTER (not KEYSERLING), p. 440.
1875a *Productus weyprechti* TOULA (not TOULA 1874), p. 138, pl. 1, figs. 4a–c.
1875c *Productus weyprechti* TOULA (not TOULA 1874), p. 234, pl. 6, figs. 2a–c.
1914 *Productus duplex* WIMAN, p. 65, pl. 14, figs. 3–7.
1916 *Productus weyprechti* TSHERNYSCHEW and STEPANOV (not Toula 1874), p. 61, pl. 7, figs. 5–6.
1937 *P.* (*Linoproductus*) *duplex* FREBOLD, p. 27, pl. 9, figs. 3, 3a.
1937a *P.* (*Thomasina*) *weyprechti* STEPANOV (not TOULA 1874), p. 128, pl. 2, figs. 8–9.

Type data

Lectotype (here selected): the specimen figured by WIMAN 1914, pl. 14, fig. 5, now in Uppsala Museum.

Type locality: Brachiopod Chert, Kapp Wijk, Dicksonfjorden, Spitsbergen.

Description

Large *Muirwoodia*, rectangular in outline, width greater than length and greatest at hinge line. Pedicle valve rounded geniculate with broad flattened umbo not transgressing hinge line; umbonal angle 120°. Median sulcus deep, extending from umbo to anterior margin. Ears strongly arched and merging with flanks, not projecting laterally. Visceral humps rounded in cross section. Brachial valve deeply concave with narrow, sharply ridged median fold. Long trail developed anterior to rounded geniculation. Sculpture of prominent rounded costae, narrower than the intercostal sulci, numbering 13–15 in 10 mm, sometimes running slightly irregularly and increasing by intercalation. Spines few; row of small cardinal spine bases and larger halteroid spine bases symmetrically placed on pedicle valve flanks and trail. Shell thin, easily crushed and distorted. Shell cavity very low.

Interior of pedicle valve with narrow adductor muscle platform and broad diductor muscle impressions lining visceral hollows. Ears sharply demarcated from visceral disc. Posterior border thickened along hinge line. Interior of brachial valve with broad, low, trilobed cardinal process with sulcate median lobe and deeply excavated lateral lobes. Stout endospines in irregular transverse rows at geniculation. Brachial ridges prominent and given off laterally.

Discussion

WIMAN compared this species with *P. multistriatus* MEEK, *P. mammatus* KEYSERLING and *P. weyprechti* TOULA. It is conspecific with the specimens figured by TOULA in 1875 c but not with his original specimens of *weyprechti*. *M. multistriatus* (MEEK 1877, pl. 8, figs. 3, 3 a–e) has a more evenly convex pedicle valve and a narrower, more inflated umbo than *M. duplex*. *M. groenlandica* DUNBAR (1955, p. 103, pl. 16, figs. 1–17) is a smaller, less transverse species with narrow laterally projecting ears. The specimens described by TSCHERNYSCHEW and STEPANOV (1916) resemble *M. duplex* in these characters.

Occurrence

M. duplex is common in the Brachiopod Chert of Isfjorden and Bellsund. The specimens described here are from the Middle Brachiopod Chert of Sassenfjorden, Gipshuken (S. M. E 18268, E 18806–9); Templet (S. M. E 18222); Rundodden (S. M. E 18083); the Brachiopod Chert of Polarisbreen, Cepheusfjellet (S. M. E 18053), and two specimens collected by LAMONT from Akseløya, Bellsund, and described by SALTER (1860) as *Productus mammatus?* (B. M. B 17989, B 85091). TSCHERNYSCHEW and STEPANOV (1916) recorded the present species from Great Bear Cape, Ellesmere Island.

Genus *Yakovlevia* FREDERICKS, 1925

1925 *Yakovlevia* FREDERICKS, p. 7.
1960 *Yakovlevia* MUIR-WOOD and COOPER, p. 323.
Genotype: *Yakovlevia kaluzinensis* FREDERICKS.

Discussion

FREDERICKS regarded *Yakovlevia* as a Chonetid genus. He figured only internal moulds of pedicle valves of *Y. kaluzinensis* (1925, pl. 2, figs. 64–6).

Productus impressus TOULA was put provisionally into *Yakovlevia* by MUIR-WOOD and COOPER (1960).

Yakovlevia impressa (TOULA)
Plate 14, figs. 1–4, text fig. 16

1875c *Productus impressus* TOULA, p. 236, pl. 5, figs. 1a–c.
1914 *Productus impressus* WIMAN, p. 76, pl. 18, figs. 7–9, pl. 19, figs. 22–27.
1936 *Productus impressus* STEPANOV, p. 119, pl. 3, fig. 2.
1937a *Productus* (*Jakowlevia?*) *impressus* STEPANOV, p. 174, pl. 3, figs. 8–9.
1937 *Productus* (*Linoproductus?*) *impressus* FREBOLD, p. 26, pl. 9, figs. 1–2.
1958 *Productus impressus* FORBES, p. 475.

Type data

Lectotype (here selected): the specimen figured by TOULA 1875 c, pl. 5, figs. 1 a–c.

Type locality: Akseløya, Bellsund, Spitsbergen.

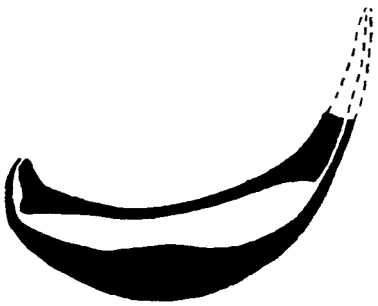

Fig. 16. *Yakovlevia impressa* (TOULA). Median longitudinal section of S. M. E 18651, × 1.

Description

Large; outline trapezoidal to rectangular, wider than long, greatest width at hinge line. Pedicle valve gently convex, with shallow median sulcus, extending from umbo to anterior margin. Ears large, triangular, separated from flanks by broad depression. Umbo low, and broad. Cardinal extremities pointed or rectangular. Low anacline interarea, 0.8 mm wide at umbo, tapering to 0.2 mm on ears, frequently damaged. On several shells false interarea, about 2 mm wide, is exposed where posterior border of brachial valve has moved anteriorly due to slight crushing of shell. Brachial valve concave, with low, narrow, median fold; no interarea, small lophidium. Shell cavity low (see text figure 16).

Both valves covered with fine, angular costae, narrower than intercostal sulci, and numbering 20–25 in 10 mm. Spine bases small, limited to cardinal row on pedicle valve.

Pedicle valve interior has prominent, narrow, adductor muscle platform divided by median groove. Anterior adductor muscle impressions occupy elongate oval areas on platform and posterior impressions shorter oval areas, flanking platform at its posterior end. Both sets dendritic. Divaricator muscle impressions subrectangular, lining thickened visceral hollows, bounded laterally by sharp ridge. Brachial valve interior has flat visceral disc, bounded laterally and anteriorly by thickened geniculation, raised into ridge on lateral borders. Posterior border bevelled and posterior margin sharp. Cardinal process sessile, broad, trilobed, median lobe deeply sulcate, lobes converging dorsally. Lateral ridges short, broad, adjoining posterior platform and not continuous with lateral border ridges. Adductor muscle field rounded triangular, posterior and anterior adductor impressions both dendritic and divided by low ridge. Low, medianly grooved septum dividing adductor field, replaced anteriorly by breviseptum which becomes high and blade-like at its termination. Brachial ridges elongate, kidney-shaped. In some specimens floor of valve between brachial ridges and breviseptum is raised into paired cone-like structures resembling brachial cones of *Gigantoproductus*. Surface of visceral disc coarsely pitted, endospines at posterior border; trail with minute recumbent endospines.

Discussion

TOULA's figured specimen is not complete but shows the characteristic external form of the species. TOULA (1875 c, p. 236) compared it with a variety of *Productus giganteus* figured by DE KONINCK (1847, pl. 4, fig. 1 a). *P. giganteus* was recognized

by VON BUCH (1847) in KEILHAU's collection from Miseryfjellet, Bjørnøya. The specimens were probably *Y. impressa.*

TOULA mentioned that cardinal spines were present. These are obscure on most specimens since the thin cardinal edge of the valves is often damaged and WIMAN could not see them on the specimens he described. WIMAN described the shell as flat and TOULA as strongly enrolled. This led FREBOLD (1937) to doubt that WIMAN's specimens were conspecific with TOULA's. The difference may be explained partly by crushing of the valves and partly by the subjectiveness of description. The presence of an interarea on the pedicle valve was discussed by STEPANOV (1937).

The affinities of *Y. impressa* are uncertain. It resembles *Gigantoproductus*, particularly in the large, divided adductor muscle impressions and the conical thickenings in the brachial valve. Another Lower Carboniferous (Missisippian) genus *Marginirugus* SUTTON (1938, p. 559), also of doubtful affinities, has a superficial resemblance to *Y. impressa* but has a more convex pedicle valve, prominent cardinal spines and no trace of a pedicle interarea. The cardinal process has a similar form but the lateral ridges are more strongly developed and the adductor muscle field is smaller.

Occurrence

Y. impressa appears to be restricted to the Spirifer Limestone of Svalbard, where it has been collected from Isfjorden, Bellsund, and Miseryfjellet, Bjørnøya. The specimens described here are from Tyrellfjellet (S. M. E 17648, (E 18681–3); Gipshuken (S. M. E 17521–3); Bjonahamna (S. M. E 17839, E 18648–61); and west of Kapp Schoultz (S. M. E 18210–3). At Bjonahamna it is extremely common, pockets in the Spirifer Limestone consisting entirely of these shells cemented together. They are silicified and readily weather out.

Subfamily Monticuliferinae MUIR-WOOD and COOPER, 1960

Genus *Monticulifera* MUIR-WOOD and COOPER, 1960, p. 327.
Genotype: *Productus intermedius* ABICH var. *sinensis* FRECH.

Monticulifera? lovéni (WIMAN)
Plate 14, figs. 7–9

1914 *Productus lovéni* WIMAN, p. 72, pl. 17, figs. 12–18.
1917 *Productus lovéni* GRÖNWALL, p. 584, pl. 28, fig. 23.

Type data

Lectotype (here selected): the specimen figured by WIMAN, 1914, pl. 17, figs. 12, 17.

Type locality: Lovénberget, Ny Friesland, Spitsbergen.

Description

Outline rounded quadrate with greatest width across middle of visceral disc. Valves geniculated, visceral disc and trail with low convexity. Pedicle valve with

umbo pointed, slightly inflated; venter flattened; sulcus absent; ears rounded, merging with flanks. Brachial valve similar in form and shell cavity low; shell thin and easily crushed. Sculpture of slightly irregular capillae, about 15 in 5 mm, 2–3 coalescing to form a swollen spine base (monticule). Monticules elongated on visceral disc, circular on trail, bearing spines on pedicle valve, and numbering 15–20 in 1 cm square. Internal characters not seen.

Discussion

WIMAN figured the internal characters of *Productus lovéni* but judging from his original material it is doubtful if the brachial valve interior (WIMAN 1914, pl. 17, fig. 18) belongs to this species. The genus *Monticulifera* was based on productids from the Permian of China having a characteristic sculpture. The monticules of *P. lovéni* are smaller, less numerous and more comparable to the spine ridges of *Cancrinella*. However, in the size and form of the valves *lovéni* resembles *Monticulifera*.

Occurrence

Apart from a single specimen from a boulder at Eskimo Naze, Holms Land, north-east Greenland, this species has been recorded only from Spitsbergen. Specimens described here were from the Brachiopod Chert, Mertonberget, Chydeniusbreen (S. M. E 18025–6, E 18036); and the scree *ex* Brachiopod Chert, south of Kapp Wijk, Nordfjorden (S. M. E 18294).

Subfamily Striatiferinae MUIR-WOOD and COOPER, 1960

Genus *Striatifera* CHAO, 1927

1927 *Striatifera* CHAO, p. 94.
1960 *Striatifera* MUIR-WOOD and COOPER, p. 328.
Genotype: *Mytilus striatus* FISCHER DE WALDHEIM.

Striatifera? sp.
Plate 10, figs. 10–11

Ten poorly preserved pedicle valves (S. M. E. 18755–64), resemble small *Striatifera cora-similis* SARYCHEVA, a species from the middle Viséan, C_1^{al}, of the Moscow basin. They were collected from the scree *ex*. transition beds between the Billefjorden Sandstone and Lower Gypsiferous Series, Odellfjellet.

Suborder CHONETOIDEA MUIR-WOOD, 1955
Superfamily Chonetacea SHROCK and TWENHOFEL, 1953
Family Chonetidae WAAGEN, 1884

Genus *Chonetes* FISCHER, 1837, emend. PAECKELMANN, 1930. p. 215

Genotype: *Orthis striatella* DALMAN.

Chonetes sp.
Plate 15, fig. 1

A few incomplete valves resemble *Chonetes granulifera* OWEN in general appearance. The best preserved pedicle valve (S. M. E 17963) is gently convex with semi-circular outline, postero-lateral slopes flattening to form ears; sulcus absent (it is slightly developed on other specimens); hinge width 29 mm. Sculpture of fine capillae, about 20 in 5 mm. Interior of pedicle valve smooth posteriorly, pustulose anteriorly. Three smooth longitudinal ridges occupy site of adductor muscle impressions, the central one being lower and narrower than the other two. Interareas and details of brachial valve not seen.

Occurrence

Cora Limestone, Ymerdalen, Bjørnøya (S. M. E 17963, E 18457–60).

Genus *Chonetina* KROTOW, 1888

1885 *Chonetella* KROTOW, not WAAGEN 1884.
1888 *Chonetina* KROTOW, p. 500.

Diagnosis

Chonetids with moderate to strongly convex pedicle valve with narrow and pronounced median sulcus. Brachial valve concave and bearing narrow median fold.

Genotype: *Chonetella artiensis* KROTOW.

Chonetina superba sp. nov.
Plate 15, figs. 2–6

1902 *Chonetes variolata* TSCHERNYSCHEW, (not D'ORBIGNY), p. 597, pl. 27, figs. 9–11.
1937 *Chonetes variolata* FREBOLD, (not D'ORBIGNY), p. 12, pl. 9, fig. 8.
?1937 *Chonetes* cf. *variolata* STEPANOV, p. 111, pl. 1, fig. 8.

Type data

Holotype: S. M. E 17721.
Paratypes: S. M. E 17714, E 17719, E 17722, E 17724.
Type locality: Middle Brachiopod Chert, 150 m above the base of Spirifer Limestone, Gipshuken, Bünsow Land.

Diagnosis

Large *Chonetina* with moderately convex pedicle valve, rounded visceral humps and extensive, flattened ears. Shell cavity very low.

Description

Large, moderately concavo-convex shells, rounded rectangular in outline. Hinge line occupies greatest width, up to 55 mm (normally 40–45 mm). Length approximately half width. Pedicle valve regularly arched from posterior to anterior margin. Median sulcus variable, narrow and constant in width in holotype.

Large, flattened ears separated from visceral disc by broad depressions. Pedicle interarea about 2 mm high, anacline, and with growth lirae parallel to hinge line. Delthyrium wide, covered by low, convex deltidium. Six or more stout cardinal spines present on each side of umbo and directed postero-laterally.

Brachial valve concave, posterior border steeper than anterior. Ears flattened and rounded; median fold present. Interarea hypercline, 1.0 mm–1.5 mm high. Notothyrium covered by prominent convex chilidium, larger than deltidium of pedicle valve.

Shell relatively thick and appearance of surface dependent on amount of wear. Unworn shells have smooth surface, covered with fine tangential spinules, about 50 in 5 mm square. Beneath this surface, layers of shell folded into fine capillae about 23 in 5 mm, normally seen at surface of fossil. Troughs between these refolded transversely to form little pits which appear as pustules on interior of shell. Posteriorly valves become thickened, and pustules become larger and lose their linear arrangement.

Interior of valves not seen. An external mould of the cardinal process shows it to be quadrifid posteriorly.

Discussion

The species has previously been recorded as *Chonetes variolata* (D'ORBIGNY). D'ORBIGNY (1842, pl. 4, figs. 10–11) figured a pedicle valve from the Lower Permian of Bolivia. This is smaller than that of *Chonetina superba* and with a broader median sulcus. Another specimen from Bolivia was figured by KOZLOWSKI (1914, pl. 8, fig. 16). This is equal in size to the largest specimen of *C. superba* but has a quadrate outline with relatively small ears and an extremely shallow sulcus. The arctic and Russian form is distinct from the Bolivian one; thus I have described it as a new species. *Chonetina superba* is similar to *Chonetes puebloensis* R. H. KING (1938, p. 262, pl. 37, figs. 1–6) but is smaller, less alate, and has a more prominent sulcus.

Occurrence

TSCHERNYSCHEW recorded this species from the Lower Permian of the Urals and the Timan. In Spitsbergen it is found in the Middle Brachiopod Chert of Sassenfjorden, Gipshuken (S. M. E 17711–26, E 18813–4); Rundodden (specimen lost); Kapp Wijk (S. M. ?E 18297); Marmierfjellet (S. M. E 18454); Oscar II Land, Skivefjellet (X 656); Svarttårnen (X 670); and Kongsfjorden, west of Thiisbukta, (S. M. ?E 18079).

Genus *Mesolobus* DUNBAR and CONDRA, 1932, p. 136

Diagnosis

Chonetids with a pedicle sulcus containing a rounded median fold. Corresponding median sulcus on brachial fold. Median septum in brachial valve.

Genotype: *Chonetes mesolobus* NORWOOD and PRATTEN.

Mesolobus? sp.
Plate 15, fig. 10

Description

Gently concavo-convex shell with rounded quadrilateral outline, hinge line forming greatest width (9 mm). Length 6.5 mm. Pedicle valve has broad median sulcus containing low fold. Cardinal extremities flattened, forming ears. Area low, anacline. Sculpture of fine capillae, increasing by bifurcation, and numbering about 100 at anterior margin.

Interior surface of both valves bears radial rows of pustules. Pedicle valve has thin median septum in umbonal area; brachial valve a more prominent septum, highest in the centre, occupying middle two thirds of valve.

The valves show scarcely any thickening and the specimen may be immature.

Discussion

There is only one silicified specimen. The central fold is very slight and its extent is obscured posteriorly by matrix adhering to the shell. It superficially resembles *Chonetes lobata* SCHELLWIEN but is only half the size.

Occurrence

Lower Wordiekammen Limestone, Teltfjellet (S. M. E 18186). *Mesolobus* is characteristic of the Lower Pennsylvanian of North America.

Genus *Paeckelmannia* LICHAREW, 1934

1930 *Tornquistia* PAECKELMANN, (not REED 1896), p. 218.
1934d *Paeckelmannia* LICHAREW, p. 509, footnote.

Diagnosis

Chonetids without a marked sulcus and having a smooth surface.
Genotype: *Leptaena* (*Chonetes*) *polita* M'COY.

Paeckelmannia forbesi sp. nov.
Plate 15, figs. 7–9

Type data

Holotype: S. M. E 18262.
Paratypes: S. M. E 18251–60.
Type locality: Upper Wordiekammen Limestone, Gipsvika, Bünsow Land, Spitsbergen.

Description

Rounded quadrangular in outline, greatest width (10–12 mm) lying across middle of valves. Pedicle valve gently to moderately convex with more or less distinct shallow sulcus. Postero-lateral slopes flattened to form ears. Area low, ?orthocline. Brachial valve slightly concave and with low, hypercline area.

Surface of valves smooth with faint growth lines and fine tangential spines numbering about 15 in 2 mm square. Interior of valves show radial rows of pustules which obscure other structures. Pedicle valve appears to have thin median septum in umbonal area.

Discussion

It is difficult, especially in the older literature, to compare figures of small and relatively featureless fossils. However, the species described above differs from most *Paeckelmannia* spp. in the outline of the pedicle valve and the form of the sulcus. It is named in honour of Dr. C. L. FORBES, assistant curator of the Sedgwick Museum.

P. polita (M'COY) and *p. ambiensis* (WAAGEN) are more convex shells; *P. laevis* (DAVIDSON) has a semicircular outline and no trace of a sulcus; *P. permiana* (SCHUMARD) has a more transverse outline; *P. novozemliaensis* LICHAREW is more convex, narrower and shows no sulcus; *P. obtusa* (SCHELLWIEN) is similar to *Paeckelmannia forbesi* sp. nov. in shape but has a width of 19 mm.

WANG (1952, p. 347) identified what are probably poorly preserved specimens of *Paeckelmannia forbesi* sp. nov. as *Chonetes latesinuata* SCHELLWIEN.

Occurrence

Upper Wordiekammen Limestone, Gipsvika (S. M. E 17373–7, E 18251–62); Teltfjellet (S. M. E 18187–8, E 18696–7, E 17064, E 17067, E 17120); Brisingefjellet (S. M. E 17343).

Lower Wordiekammen Limestone, De Geerfjellet (S. M. E 17295). Permo-Carboniferous, Cepheusfjellet, Polarisbreen, Ny Friesland (S. M. E 18449).

Paeckelmannia capitolina (TOULA)
Plate 15, figs. 11–13

1875c *Chonetes capitolinus* TOULA, p. 250, pl. 8, figs. 9a–b.
1937 *Chonetes capitolinus* FREBOLD, p. 13.
1939 *Chonetes* (*Paeckelmannia*) sp. nov. aff. *capitolinus* LICHAREW and EINOR, p. 26, 203, pl. 2, figs. 10–13.
1960 *Chonetes* (*Paeckelmannia?*) *capitolinus* HARKER, p. 53, pl. 16, figs. 11–12.

Type data

Lectotype (here selected): the specimen figured by TOULA 1875 c, pl. 8, fig. 9 a. This is in the Naturhistorisches Museum, Vienna (1875 XLI). TOULA's figure is a mirror image of the specimen. A plaster cast of the lectotype is figured here (pl. 27, fig. 11).

Type locality: Kapitol, Ekmanfjorden.

Description

Sub-rectangular in outline with greatest width (22–28 mm) at or just anterior to hinge line. Length 13–18 mm. Pedicle valve gently convex. Venter flattened on some specimens but sulcus not developed. Cardinal extremities obtuse. Pedicle

area narrow, apsacline. About six stout spine bases at cardinal border, on either side of umbo. Brachial valve flat.

Surface of both valves smooth, marked only by fine growth lirae, but appears striated or pitted when worn. Posterior part of pedicle valve interior has thin, low median septum. Brachial valve interior coarsely pustulose except in thickened umbonal region; tooth sockets and socket plates prominent. Three low smooth ridges diverge from umbo and occupy adductor muscle field.

Discussion

P. toulai DUNBAR is a smaller species with rectangular or acute cardinal extremities and a shallow sulcus. The radial lirae on the brachial valve mentioned by DUNBAR are not present in *P. capitolina*.

Occurrence

WIMAN (1914, p. 62) recorded *Chonetes capitolinus* from Lovénberget but it is not certain that the specimens really belonged to this species. *P. capitolina* occurs in the Spirifer Limestone, Kapp Wijk (S. M. E 18300); Bjonahamna (S. M. E 18566); and the Brachiopod Chert, Oslobreen, station G 859 (S. M. E 18163–7), station G 860 (S. M. E 18169–75).

Paeckelmannia cf. *permiana* (SCHUMARD, 1859)
Plate 15, figs. 14–18

cf. 1909 *Chonetes permianus* GIRTY, p. 226, pl. 20, figs. 1–3, pl. 29, figs. 1–2.
1914 *Chonetes* sp. cf. *geinitzi* WIMAN, p. 61.

Description

Small, width 8–10 mm. Outline semi-circular, greatest width slightly anterior to hinge line; cardinal extremities rounded. Pedicle valve moderately convex with flattened flanks and anterior slope. Ears small, separated from visceral disc by obscure depression. Pedicle area low, orthocline. About four spine bases along cardinal margin. Brachial valve flat, in some specimens slightly concave at anterior border; area low, hypercline. Surface of both valves smooth. Radial cracks present; probably formed during recrystallization of shell. Internal characters not seen.

Discussion

In external form these shells bear a close resemblance to *P. permiana* as figured by GIRTY. *P. novozemliaensis* LICHAREW is a similar form but appears more convex and less transverse in outline.

Like the two preceeding species *P.* cf. *permiana* is usually found concentrated in lenses, to the exclusion of other brachiopods.

Occurrence

Brachiopod Chert, Nordaustlandet, Angelinberget (R. M. S. Br. 938–40); and Nordfjorden, shore south of Kapp Wijk (S. M. E 18303–15). The specimens (about 50) from Angelinberget were determined by TSCHERNYSCHEW as *Chonetes* cf. *geinitzi* WAAGEN.

Genus *Lissochonetes* DUNBAR and CONDRA, 1932, p. 169

Diagnosis

Smooth chonetids with a prominent broad pedicle sulcus and brachial fold.

Genotype: *Chonetes geinitzianus* WAAGEN.

Lissochonetes spitzbergianus (TOULA)
Plate 15, figs. 19–21

1875a *Chonetes verneuiliana* var. *spitzbergeniana* TOULA, p. 149, pl. 1, fig. 10.
1875c *Chonetes verneuiliana* var. *spitzbergiana* TOULA, p. 231, pl. 5, fig. 4.

Type data

The drawings used by TOULA to illustrate this species are essentially the same in his two papers and were probably composite ones taken from more than one specimen. However, there is a specimen in the Naturhistorisches Museum, Vienna (1875 XLI 9) which is labelled as illustrated by TOULA (1875 c) and this specimen is taken as the lectotype. I have re-figured a replica of it here (pl. 15, fig. 19). It is poorly preserved and distorted but clearly shows the deep pedicle sulcus.

Description

Outline quadrate with greatest width at hinge line. Pedicle valve has strongly convex visceral area divided by deep median sulcus into prominent rounded visceral humps. Ears relatively large and flattened. Spine bases present at cardinal margin. Surface completely smooth. Brachial valve and internal characters unknown. Width 11 mm; length at least 6 mm.

Discussion

I have seen only two pedicle valves which appear to be conspecific with TOULA's specimen, P. M. O. A 28332, from the Brachiopod Chert of Reinodden, Bellsund, and S. M. E 18054 from scree *ex* Brachiopod Chert, Cepheusfjellet, Polarisbreen, Ny Friesland.

Suborder RHYNCHONELLOIDEA MOORE, 1952
Superfamily Rhynchonellacea SCHUCHERT, 1896
Family Camarotoechiidae SCHUCHERT and LEVENE, 1929
Subfamily Camarotoechiinae SCHUCHERT and LEVENE, 1929

Genus *Camarotoechia* HALL and CLARKE, 1894, p. 189

Diagnosis

Rhynchonellids with triangular outline, shallow pedicle and convex brachial valves. Plicae extend from umbo to anterior margin. Median septum of brachial valve divided posteriorly to form a septalium. No cardinal process. Pedicle valve with slender dental lamellae.

Genotype: *Atrypa congregata* CONRAD.

Discussion

About six isolated specimens probably belong to this genus and three of these are poorly preserved pedicle valves. As there is insufficient material with which to study internal characters, these specimens cannot be identified with certainty. *Camarotoechia* has not previously been recorded from Spitsbergen although it is possible that it has been confused with *Camerophoria*.

Camarotoechia? cf. *krotovi* (TSCHERNYSCHEW)
Plate 15, fig. 25

cf. 1902 *Rhynchonella krotovi* TSCHERNYSCHEW, p. 447, pl. 21, fig. 5.

Description

Weakly biconvex shell with rounded anterior border. Sulcus and fold low and obscure. Plicae, 10–14, flat on posterior part of valve but becoming broader and angular on anterior part. Pedicle umbo damaged but appears to be small and not to protrude far posterior to brachial umbo.

Discussion

Rhynchonella krotovi was included by STEPANOV (1937 c p. 149) in the genus *Septacamera* which is characterized by a spondylium connected to the sides of the valve by a transverse plate. Unfortunately nothing is known of the internal characters of the specimens described here.

Occurrence

Upper Wordiekammen Limestone Teltfjellet (S. M. E 18191). Cyathophyllum Limestone, Cepheusfjellet, Polarisbreen (S. M. E 18448).

Camarotoechia? sp.
Plate 16, figs. 1–3

1952 *Rhynchopora* cf. *nikitini* WANG, p. 347.

Description

Sub-tetrahedral in shape with greatest thickness near anterior border. Triangular sulcus and fold developed anteriorly. Anterior commissure multiplicate and strongly folded. Plicae, similar to those of last species, three in sulcus, four on fold and nine on each flank.

Occurrence

Upper Wordiekammen Limestone, Tyrellfjellet (S. M. E 18698); Teltfjellet (? S. M. E 17049).

Genus *Wellerella* DUNBAR and CONDRA, 1932, p. 286

Genotype: *Wellerella tetrahedra* DUNBAR and CONDRA

Wellerella? sp.

Plate 15, figs. 22–24

1914 *Pugnax osagensis* WIMAN (not SWALLOW), p. 26.

The unlabelled example mentioned by WIMAN is not conspecific with those from the Corakalk of Bjørnøya. The latter, in their external characters, resemble *Wellerella osagensis* (SWALLOW) but no certain identification can be made without a study of internal characters. I have seen no other specimens.

Occurrence

Corakalk, Ymerdalen, Bjørnøya, (R. M. S. Br. 14: Br. 998).

Superfamily Camerophoriacea GRABAU, 1936

Family Camerophoriidae WAAGEN, 1883

Genus *Camerophoria* KING, 1844

1844 *Camerophoria* KING, p. 313.
1846 *Camerophoria* KING, p. 89.
1850 *Camarophoria* KING, p. 113.

Diagnosis

Rhynchonelliform shells with a spondylium in the pedicle valve and a spatulate camerophorium (KOZLOWSKI 1929, p. 132) in the brachial valve. Crura long and spine-like.

Genotype: *Terebratula schlotheimii* VON BUCH.

Discussion

CONRAD (1839, p. 59) designated *Terebratula schlotheimii* as the genotype of *Stenocisma*. However, the specimens he described were misidentified as *T. schlotheimii* and thus *Camerophoria* is not to be considered a junior synonym of *Stenocisma*, (I. C. Z. N. Opinion 168). DUNBAR (1955, p. 119) discusses this question in full.

Camerophoria spitzbergiana STEPANOV

Plate 16, figs. 4–9, text fig. 17

1937a *Camerophoria spitzbergiana* STEPANOV, p. 157, 182, pl. 9, fig. 11.
1950 *Camerophoria biplicata* FREBOLD, (not STUCKENBERG), p. 67, pl. 16, figs. 3, 3a.

Type data

STEPANOV figured only one specimen and this must be taken as the type.

Type locality: Spirifer Limestone, Tempelfjorden, Spitsbergen.

Description

Biconvex shells, sub-tetrahedral in shape and rounded triangular in outline. Pedicle valve slightly convex, developing broad, flat sulcus in anterior half which curves into a tongue lying at about 120° to lateral commissure. Pedicle umbo narrow, inflated and sharply hooked over brachial umbo. Minute pedicle opening at tip of umbo.

Brachial valve strongly convex with rhynchonelliform fold on anterior half. Valves smooth posteriorly. Rounded plicae present anteriorly, 2–3 in sulcus, 3–4 on fold, and usually 2–3 on anterior part of flanks. Anterior and lateral margins of valves thin and appear to have been produced into frills.

Internal characters studied from serial sections (text figure 17). Pedicle valve has sessile spondilium and brachial valve camerophorium with short median septum. Anteriorly spondylium and camerophorium form a tube, inside which lie long slender crura.

Discussion

The sculpture serves to distinguish this species from most other *Camerophoria* spp. In this character it resembles *C. biplicata* STUCKENBERG. TSCHERNYSCHEW's figures of *biplicata* (TSCHERNYSCHEW 1902, pl. 50, figs. 8–10) show that this species has a rostrate pedicle umbo which breaks the triangular outline of the shell. *C. biplicatiformis* LICHAREW has no intercamerophorial plate and the wings of the camerophorium are united with the hinge plate. Some specimens of *C. schlotheimii* have a similar plication but have a sub-pentagonal outline.

Occurrence

The specimens described here are topotypes, from the Spirifer Limestone, Bjonahamna, Tempelfjorden, (S. M. E 18490–6).

Camerophoria sp. aff. *spitzbergiana* STEPANOV
Plate 16, figs. 10–11

This species is similar to the last but the sulcus and fold are less well developed. Most of the specimens are crushed but in one an anterior frill is well preserved (pl. 28, fig. 15). The umbonal areas are smooth; the rest of the shell has low rounded costae, becoming plicae at the anterior border, numbering 12–18 in the pedicle valve, 4–5 of these lying in the sulcus. The internal characters are similar to those of the last species and the smaller specimens closely resemble *spitzbergiana*. It appears to occur higher stratigraphically but the number of specimens collected is small and further collecting may show it to overlap with *C. spitzbergiana*.

Occurrence

Middle Brachiopod Chert, Gipshuken (S. M. E 17678–83, E 18267); west of Thiisbukta, Kongsfjorden, (S. M. E 18080).

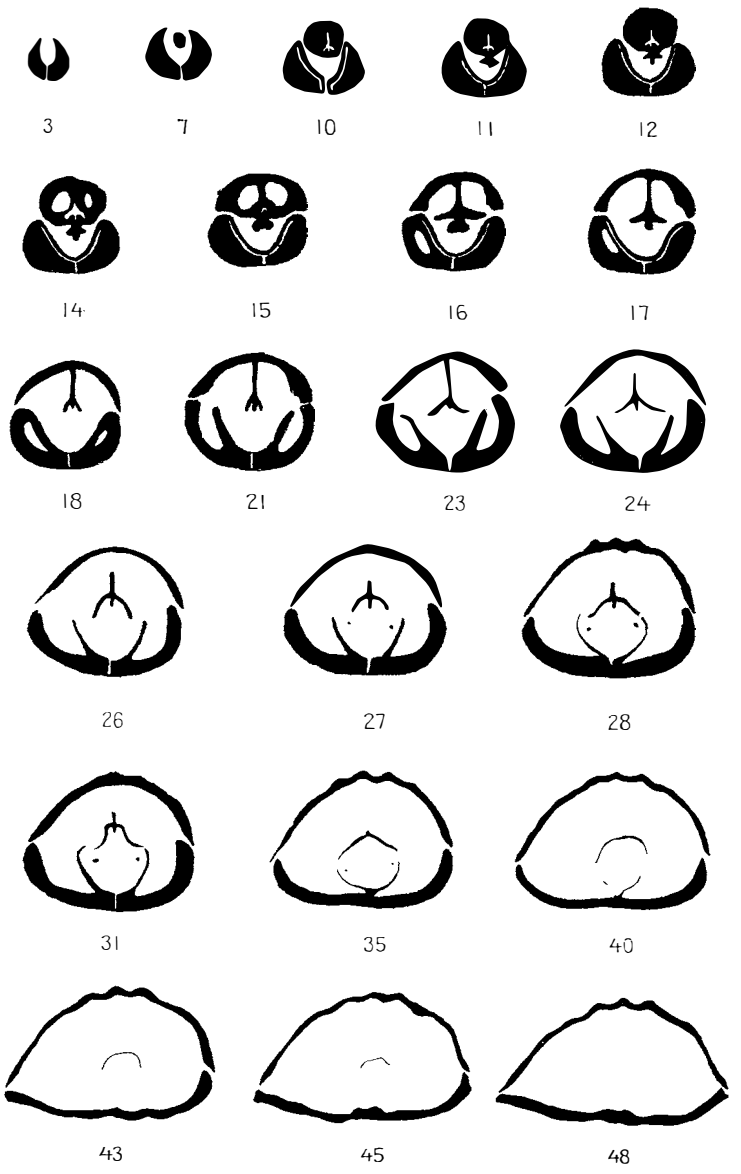

Fig. 17. *Camerophoria spitzbergiana* STEPANOV. Transverse sections of S.M.E 18495, × 2. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

Camerophoria cf. *mutabilis* TSCHERNYSCHEW

Plate 16, figs. 12

cf. 1902 *Camerophoria mutabilis* TSCHERNYSCHEW, p. 491, pl. 22, fig. 18, pl. 23, fig. 10, pl. 45, figs. 1–15, pl. 46, fig. 14, text figs. 18–20.

? 1911 *Camerophoria purdoni* HOLTEDAHL (not DAVIDSON), p. 18, pl. 2, fig. 7.

? 1937a *Camerophoria mutabilis* STEPANOV, p. 158, pl. 9, fig. 12.

? 1937 *Camerophoria* sp. indet. I & II FREBOLD, p. 43, pl. 11, figs. 2–5.

Description

Outline triangular, width greater than length. Pedicle valve slightly convex with broad sulcus occupying half or more of width at anterior border. Brachial valve strongly convex with prominent median fold. Anterior border of valves not truncated.

Plicae run from umbo to anterior border and number about five on sulcus and fold and about six on each side. Pallial markings preserved on internal moulds.

Discussion

The specimens are incomplete and distorted but resemble the variable species *C. mutabilis*. They differ from the preceding species in the more angular plicate sculpture.

Occurrence

Middle Brachiopod Chert, Gipshuken, (S. M. E 17655, E 18786); Brachiopod Chert, Skivefjellet (X 647.1–.2); Svarttårnen (X 671); Bellsund (R.M.S. Br 66a–d).

Genus *Laevicamera* GRABAU, 1936

1936 *Laevicamera* GRABAU, p. 87, footnote.

Diagnosis

Smooth Camerophoriidae with a small spondylium duplex.

Genotype: *Laevicamera yunnanensis* GRABAU.

Laevicamera cf. *arctica* (HOLTEDAHL)

Plate 16, figs. 13–16

1911 *Camerophoria pentameroides* HOLTEDAHL, (not TSCHERNYSCHEW), p. 19, pl. 2, figs. 5-6.
cf. 1924 *Camerophoria sella* var. *arctica* HOLTEDAHL, p. 34, pl. 21, figs. 1–2.
cf. 1939 *Camerophoria sella* var. *arctica* LICHAREW and EINOR, pl. 208, pl. 14, fig. 5.

Description

Globose terebratuliform shells with rounded triangular outline. Pedicle valve convex with narrow, V-shaped median groove, ?deepening and broadening anteriorly into V-shaped sulcus. Anterior part of valves missing in all specimens. Pedicle umbo inflated and arched over brachial umbo.

Brachial valve more strongly convex than pedicle, developing anteriorly low rounded fold with central keel. Anterior commissure deduced from form of growth lines to be uniplicate. Surface entirely smooth with fine growth lines.

Discussion

As far as can be seen these shells resemble *L. sella* var. *arctica*. They are larger than *L. sella* (KUTORGA) and do not appear to have such a sharply keeled fold and sulcus. *L. arctica* is more globose and less elongated than *L. pentameroides* (TSCHERNYSCHEW). HOLTEDAHL's (1911) figured specimen is conspecific with those described here.

Occurrence

L. arctica occurs in the Upper Carboniferous of Novaya Zemlya. The form described here was recorded by HOLTEDAHL from the Scheteligfjellet Beds, Brøggerhalvøya. The present specimens are from Passage Beds, Jacksonfjellet (S. M. E 17253); Lower Wordiekammen Limestone, Führmeisterdalen, Tempelfjorden (S. M. E 17284–7); and Cyathophyllum Limestone, Pachtusovfjellet, Ny Friesland (S. M. E 18857–8).

Laevicamera sp.
Plate 16, fig. 17

A single specimen (S. M. E 17971) from the Cora Limestone of Ymerdalen, Bjørnøya, is less globose than *L.* cf. *arctica*, and lacks a median groove in the pedicle valve. Towards the anterior the pedicle valve shows obscure costae but the anterior part of the shell is missing.

Superfamily Rhynchoporacea MOORE, 1952
Family Rhynchoporidae MUIR-WOOD, 1955

Genus *Rhynchopora* KING, 1865

1865 *Rhynchopora* KING, p. 124.
1955 *Rhynchopora* DUNBAR, p. 113.

Diagnosis

Rhynchonelliform brachiopods with punctate shell. Pedicle valve has well-developed dental lamellae; brachial valve a median septum supporting a small cruralium.

Genotype: *Terebratula geinitziana* VERNEUIL.

Rhynchopora nikitini TSCHERNYSCHEW
Plate 16, figs. 18–21, text fig. 18

1874 *Rhynchonella* (*Camerophoria*) *crumena* TOULA, (not MARTIN), p. 273.
1875a *Camerophoria crumena* TOULA, (not MARTIN), p. 137, pl. 1, figs. 3a–b.
1875c *Rhynchonella* cf. *pleurodon* TOULA, (not PHILLIPS), p. 237, pl. 8, fig. 3.
1889 *Rhynchopora nikitini* TSCHERNYSCHEW, p. 369, pl. 6, fig. 20.
1914 *Rhynchopora nikitini* KOZLOWSKI, p. 84, pl. 9, figs. 67–70.
1914 *Rhynchopora nikitini* WIMAN p. 26, pl. 1, figs. 13–20.
1937a *Rhynchopora nikitini* STEPANOV, p. 159, pl. 9, fig. 13.
1958 *Rhynchopora nikitini* FORBES, p. 475.

Description

Shell rounded pentangular in outline, slightly wider than long and greatest width across centre of valves. Greatest height at anterior margin which is truncated, giving triangular lateral profile. Pedicle valve slightly convex with flattened flanks,

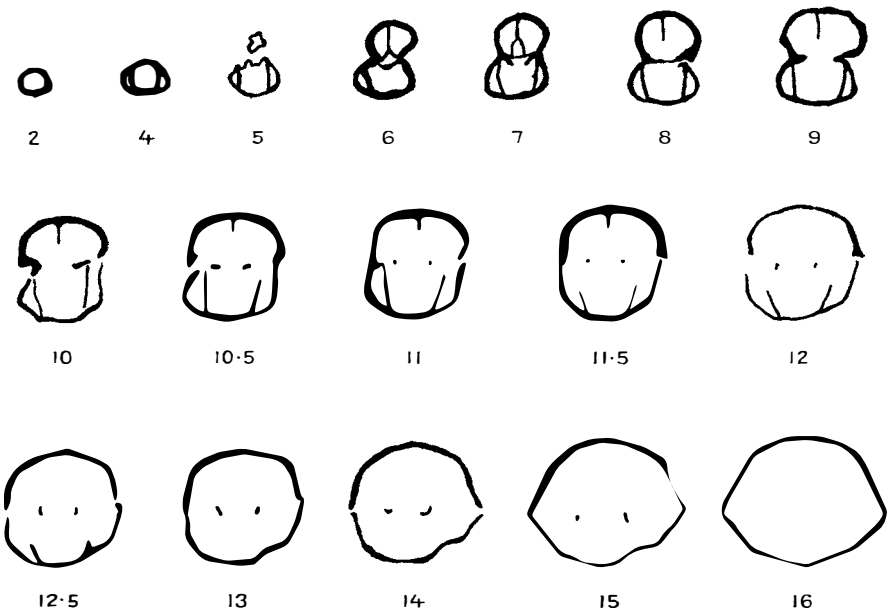

Fig. 18. *Rhynchopora nikitini* TSCHERNYSCHEW. Transverse sections of S.M.E 18567, × 2. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

broad sulcus in anterior third, and anterior tongue at 90° to lateral commissure. Pedicle umbo narrow and pointed but slightly convex and not over-arching brachial umbo. Palintrope well defined, slightly convex and smooth. Brachial valve more convex, with median fold of variable form in anterior third.

Both valves sculptured with plicae, broader than interplical sulci, low and rounded posteriorly, becoming higher and angular towards anterior border; but on truncated anterior plicae are broad and flattened, and each bears a fine median intraplical groove. Anterior end of each plica forked. Usually five, sometimes six plicae on fold, four in sulcus; 6–8 lateral plicae on brachial valve, 7–9 on pedicle valve. Shell traversed by numerous punctae, circular in cross section, about 0.025 mm in diameter, and about 60 in 1 mm square, but showing no distinct pattern.

Internal characters studied from serial sections (see text figure 18). Valves not thickened although brachial valve is the thicker. Pedicle valve has thin dental plates. In umbonal part of brachial valve, thin median septum supports small cruralium. Hinge plate, teeth and sockets obscure, probably due to shell re-crystallization.

Discussion

R. nikitini differs from most other *Rhynchopora* spp. in having a sharply truncated anterior. *R. geinitziana* has a similar form but the plicae are obsolete or effaced on the umbonal areas and, according to TSCHERNYSCHEW (*fide* DUNBAR 1955, p. 116) intraplical grooves are absent. *R. nikitini* var. *arctica* LICHAREW and EINOR (1939, p. 64) shows valves approximately equal in convexity. The specimens from Bolivia figured by KOZLOWSKI appear identical with those described here.

KOZLOWSKI (1914, p. 85) described the internal characters in detail. He mentions that the hinge plate is divided, although secondary shell deposits often give it the appearance of being undivided. An undivided hinge plate has been cited in the diagnosis of the genus *Rhynchopora* by R. E. KING (1931, p. 109) and DUNBAR (1955, p. 113).

Occurrence

R. nikitini is widespread in the Lower Permian of Russia. It has been recorded from Amdrups Land, north-east Greenland (GRÖNWALL 1917, p. 557), and arctic Canada (TSCHERNYSCHEW and STEPANOV 1916, p. 57).

In Svalbard it occurs in the Spirifer Limestone. The specimens described here are from Oslobreen, station G 859, (S. M. E 18146–50); Bünsow Land, Templet (S. M. E 17456–8); Usherfjellet (S. M. E 17497); Gipshuken (S. M. E 17570–1, E 18784–5); Tyrrellfjellet (S. M. E 18690); Wardropfjellet (S. M. E 18273–4); Bjonahamna (S. M. E 18567–74); and Bjørnøya, north shore of Lakselva (S. M. E 17927).

Rhynchopora sp.
Plate 16, figs. 22–25

A small number of specimens (S. M. E 18202–7) collected from the Upper Gypsiferous Series, about 80 m below the Spirifer Limestone, differ markedly from *R. nikitini*. The anterior border of the shell is less sharply truncated and the plicae are coarser, remain rounded, and are obscure on the umbonal parts of the valves. There are three plicae on the fold and two in the sulcus.

This form may be conspecific with *R. variabilis* STUCKENBERG. It differs from *Rhynchopora* sp. A. DUNBAR (1955, p. 116, pl. 19, figs. 25–6) in having a more pentagonal outline and less angular plicae.

Suborder SPIRIFEROIDEA ALLEN, 1940, emend. MUIR-WOOD, 1955
Superfamily Spiriferacea WAAGEN, 1883
Family Spiriferidae KING, 1846
Subfamily Phricodothyrinae CASTER, 1939, p. 144

Genus *Neophricadothyris* LICHAREW, 1934a, p. 213

Squamularia auctt. (not GEMMELLARO 1899).

Diagnosis

LICHAREW diagnosed the genus as follows:

This new generic name I propose for the forms from the Upper Carboniferous and Permian which are generally described under the name of *Squamularia*. The comparative study of the sculpture of these forms and of the real representative of *Squamularia* leads me to the conclusion that the sculpture of the former differs from that of *Squamularia*.

Neophricadothyris also differs from *Squamularia* by the disposition of the axes of spiral cones, which have their apices turned towards the cardinal extremities. From *Phricadothyris* (*sic*) this

genus differs in the same way and also by the complete absence of dental plates. Genoholotype: *Squamularia asiatica* CHAO. Upper Carboniferous – Permian. Eurasia.

Discussion

The distinction of *Neophricadothyris* from *Phricodothyris* GEORGE is not clear. In the latter genus, the spiralia are directed more or less laterally and dental lamellae are usually absent (GEORGE 1932, p. 524–5).

Neophricadothyris asiatica (CHAO)
Plate 17, figs. 1–3, text fig. 19

1902 *Reticularia lineata* TSCHERNYSCHEW, (not MARTIN) p. 574, pl. 20, figs. 9–13.
1914 *Reticularia lineata* WIMAN, (not MARTIN), p. 54.
1929 *Squamularia asiatica* CHAO, p. 91, pl. 11, figs. 12–14.
1937b *Neophricadothyris asiatica* STEPANOV, p. 40, pl. 3, figs. 8–9.
1939 *Neophricadothyris asiatica* LICHAREW and EINOR, p. 157, pl. 27, figs. 3, 6.
1958 *Squamularia guadalupensis* FORBES, (not SCHUMARD) p. 474.

Type data

Lectotype: CHAO figured three co-types. That figured by him on pl. 11, figs. 13a–d is here selected as lectotype.

Type locality: Wangchiapa Limestone, Shuicheng, West Kweichow.

Description

Outline sub-circular, or sub-trapezoidal with length greater than width. Convexity of valves variable but brachial valve always less convex than pedicle valve. Umbones strongly incurved and inflated. Sulcus and fold absent although some specimens show faint median groove in pedicle valve. Anterior commissure rectimarginate. Hinge line about half greatest width, which lies across middle of valves and attains 20 mm. Interareas small triangular.

Sculpture of concentric bands, 0.5–1 mm in width, bearing 1–3 rows of minute spine bases. The nature of these is not clearly seen as all the shells are worn but on some specimens they appear to be of two sizes, the larger being double-barrelled. Prominent ridges, parallel to growth lines, are commonly present anteriorly. Serial sections (see text figure 19) show no dental lamellae or septa in interior of valves.

Discussion

CHAO proposed the name *asiatica* for all those Upper Carboniferous and Permian forms previously referred to "*Reticularia lineata*". Taken in this broad sense, it probably includes several species. CHAO does not describe the internal characters. Among 40 specimens from one locality the external characters show a considerable variation. Thus comparisons made on external characters alone are not very trustworthy.

The specimens from the Assistance Formation, Grinnell Peninsula, described as *Squamularia asiatica* by HARKER (1960, p. 64, pl. 18, figs. 12–15) are larger, more transverse and have less convex valves and umbones than the Spitsbergen specimens and probably belong to a distinct species.

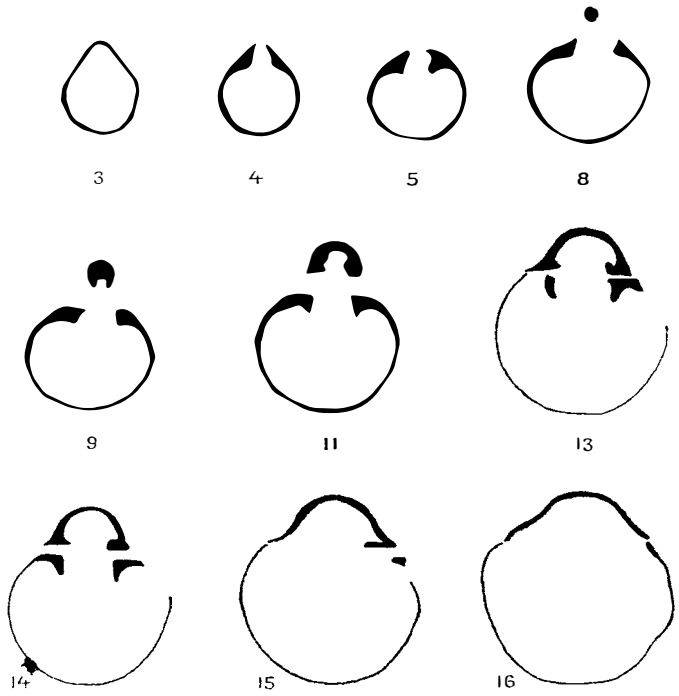

Fig. 19. *Neophricadothyris asiatica* (CHAO). Transverse sections of R.M.S. Br. 1121 j, × 2. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

Occurrence

Cora Limestone, Ymerdalen, Bjørnøya (R. M. S. Br. 1121a–t (40)); Upper Wordiekammen Limestone, Gipsvika, Sassenfjorden (S. M. E 18773).

Neophricadothyris sp. A.
Plate 17, figs. 4–5

A single specimen (P. M. O. A 26414) from the Spirifer Limestone of Sveltihel, Sassenfjorden is transverse in outline, has a lower convexity and less curved umbones than the last species. It bears some resemblance to *Squamularia ovata* CHAO (1929, p. 89, pl. 8, figs. 20–22).

Neophricadothyris sp. B.
Plate 17, fig. 6

? 1960 *Squamularia asiatica* HARKER (not CHAO), p. 64, pl. 18, figs. 12–15.

Three crushed and incomplete shells resemble those described by HARKER in size and sculpture. The latter is much coarser than that of *N. asiatica*. There are 6–7 concentric bands in 10 mm. Each band bears a row of double-barrelled spine bases along its anterior half. Between these at the edge of the band are grouped three small pustules at the corners of an equiangular triangle. Spirifer Limestone, Bjonahamna (S. M. E 18562–4).

Subfamily Spiriferinae King, 1846, emend. SCHUCHERT, 1913

Genus *Spirifer* SOWERBY, 1818

Diagnosis

Shell generally transverse in outline, with a pedicle sulcus and brachial fold. Costate sculpture on both valves not differentiated on the sulcus and fold. Costae simple, dividing on the posterior area but remaining subequal in size and not forming fasciculae. Strong delthyrial supporting lamellae in the pedicle valve.

Genotype: *Anomites striatus* MARTIN.

Spirifer striato-paradoxus TOULA
Plate 18, fig. 2

1874 *Spirifer striato-paradoxus* TOULA, p. 271, pl. 1, figs. 2a–c.
1875c *Spirifer striato-paradoxus* TOULA, p. 254, pl. 8, fig. 1.
1875c *Spirifer striatus* var. *princeps* TOULA, p. 254, pl. 8, fig. 2.
?1883 *Spirifer marcoui* WAAGEN, p. 510, pl. 47, figs. 1–3c.
1902 *Spirifer ravana* TSCHERNYSCHEW (not DIENER), p. 532, pl. 49, figs. 2–3.
?1902 *Spirifer marcoui* TSCHERNYSCHEW, p. 533, pl. 6, fig. 9, pl. 12, fig. 3.
1914 *Spirifer ravana* WIMAN (not DIENER) p. 43, part, pl. 6, figs. 1–2 only.
1914 *Spirifer marcoui* WIMAN, p. 44, pl. 6, figs. 3–7, pl. 7, figs. 9–11.
1931 *Spirifer* cf. *marcoui* FREBOLD, p. 16, pl. 4, fig. 2.
1931 *Spirifer ravana* FREBOLD (not DIENER), p. 39, pl. 4, figs. 1–1a, pl. 5, fig. 1.
1933 *Spirifer cameratus* FREBOLD (not MORTON), p. 15, pl. 1, fig. 4.
1937a *Spirifer condor* STEPANOV (not D'ORBIGNY), p. 141, pl. 7, fig. 3.
1937 *Spirifer cameratus* FREBOLD, (not MORTON), p. 48, pl. 2, fig. 3.
?1939 *Spirifer condoriformis* EINOR, p. 209, pl. 14, figs. 8–9.
?1939 *Spirifer striatus* var. *tenuicostatus* EINOR, p. 209, pl. 15, figs. 1–2, pl. 16, fig. 1.
1950 *Spirifer ravana* FREBOLD, (not DIENER), p. 57, pl. 4, figs. 3, 3a, 6.
1950 *Spirifer marcoui* FREBOLD, p. 58, pl. 4, fig. 2.
1955 *Spirifer striato-paradoxus* DUNBAR, p. 131, pl. 23, figs. 1–7, pl. 24, figs. 1–5, pl. 28, figs. 1–6.
1958 *Spirifer ravana* FORBES, (not DIENER), p. 475.
1960 *Spirifer striato-paradoxus* HARKER, p. 67, pl. 19, figs. 1–7.

Type data

Lectotype (here selected): the specimen figured by TOULA 1875 c, pl. 8, fig. 1. The specimens figured earlier by TOULA (1874) were fragmentary and appear to be lost. The lectotype is preserved in the Naturhistorisches Museum, Vienna, (1875 XLI 24).

Type locality: North of Kapp Waern, Nordfjorden, Spitsbergen.

Description

Large shells attaining 130 mm in width, extended transversely, with greatest width at hinge line. Outline trapezoidal to rectangular. Cardinal extremities pointed to rounded. Young shells more extended laterally, later growth being largely anteriorly. Pedicle valve evenly convex longitudinally, sometimes flattening anteriorly. Sulcus rounded to sub-angular, beginning at umbo and increasing in width and depth anteriorly. Umbo broad, not protruding far posterior to hinge

line. Interarea moderately high and slightly concave. Delthyrium broadly triangular.

Brachial valve flanks equal in convexity to pedicle valve. Median fold typically high and narrow with angular crest but in some specimens low and broad. Umbo small, broad and not overarching narrow interarea. Notothyrium broad.

Costae sharp or rounded in cross section and generally slightly broader than intercostal sulci, numbering 5–9, usually seven in 10 mm and increasing by division but not forming fasciculae; shell not plicated. Shells partly exfoliated and silicified and no finer sculpture visible, although growth lines sometimes prominent.

Interior of pedicle valve with stout hinge teath and strong dental lamellae, reaching floor of valve posteriorly. Interareas strengthened by thickened posterior border, and small apical callosity present. Muscle field elongate-oval, bounded by low angular ridge continuous posteriorly with dental lamellae. Adductor impressions longitudinally ridged and occupying slightly raised median strip. Interior of brachial valve with large tooth sockets and crurae. Cardinal process sessile, finely ridged longitudinally.

Discussion

Although TOULA's specimens are fragmentary (the lectotype is an internal mould of a pedicle valve with shell present only on the umbo and cardinal area on one side), there can be little doubt that the large spirifers, common in the Spirifer Limestone and showing no fasciculation of the costae, belong to *S. striato-paradoxus*. However, I have separated forms with a sub-circular muscle field, shorter delthyrial supporting lamellae and distinctly plicated shells as a new species.

TOULA's species was ignored by authors describing arctic Permian brachiopods until DUNBAR (1955) identified with it the large spirifers from central east Greenland. He noticed the close resemblance, at least on external characters, with *S. marcoui* WAAGEN. It has also been identified with other large spirifers of *striatus* type. *S. condor* D'ORB. has a broader sulcus and a broader, lower fold. *S. cameratus* MORTON is smaller, has a less pronounced and broader fold and sulcus and broader and less numerous costae (see COOPER 1944, p. 325, pl. 125, figs. 5–6). *S. ravana* DIENER is similar to the present species. DIENER separated it from *S. marcoui* only by the slightly folded or plicated shell (see discussion of *Spirifer* sp. nov.). *S. neostriatus* FREDERICKS resembles *S. striatoparadoxus* in its large size but, judging from FREDERICKS' figures (FREDERICKS 1925, pl. 4, figs. 111–112), has a shallower sulcus and a distinct plication of the shell. Unfortunately the internal characters of these spirifers either have not been fully described or are entirely unknown.

Occurrence

Spirifer striato-paradoxus is abundant in the Spirifer Limestone of Svalbard. The specimens described here are from Spitsbergen, Bünsow Land, Templet (S. M. E 18223); Bjonahamna (S. M. E 18595–9); Gipshuken (S. M. E 18674); Tyrrellfjellet (S. M. E 18687); Oscar II Land, Skivefjellet (X 651, X 658).

Bjørnøya, Miseryfjellet (S. M. E 17940–2, E 18343, E 18347–9); Lakselva (S. M. E 17929, E 18339); east bay of Herwighamna (S. M. E 18456); Lundenæringane (S. M. E 17920–1). Outside Svalbard it occurs in central east Greenland, and Grinnell Peninsula, Devon Island. Some of the described forms from the Permian of Novaya Zemlya probably belong here.

Spirifer striato-plicatus sp. nov.
Plate 17, figs. 7–9, plate 18, fig. 1

1914 *Spirifer ravana* WIMAN, (not DIENER), p. 43, part, pl. 5, figs. 17–19 only.
?1925 *Spirifer fasciger ambiensis* FREDERICKS, (not WAAGEN), p. 28, pl. 4, fig. 113.
1937a *Spirifer ravana* STEPANOV, (not DIENER), p. 142, pl. 7, figs. 5–6.
1958 *Spirifer fasciger* FORBES, (not KEYSERLING), p. 475.

Type data

Holotype: S. M. E 18588.

Paratypes: S. M. E 18328, E 18350, E 18583, E 18585, E 18587, E 18591, E 18593.

Type locality: Spirifer Limestone, Bjonahamna, Tempelfjorden, Spitsbergen.

Diagnosis

Large spirifers with prominent sulcus and broadly rounded brachial fold. Valves with 3–4 plications on each side, sculptured with costae, not forming fasciculae. Muscle impressions in pedicle valve sub-circular. Delthyrial supporting lamellae small.

Description

Shell large, 70–100 mm in width, sub-pentagonal in outline and extended transversely. Valves moderately and equally convex. Greatest width at or slightly anterior to hinge line. Cardinal extremities rounded or angular. Pedicle valve flattened transversely, with rounded or sub-angular sulcus, beginning at umbo and rapidly broadening and deepening to anterior border where it extends as rounded tongue, sometimes sharply geniculated. Anterior commissure uniplicate. Interarea low, concave, apsacline, changing from orthocline almost to catacline during growth. Delthyrium wide, equiangular.

Brachial valve, in transverse section, more convex than pedicle valve; has rounded median fold, broadening anteriorly; and orthocline interarea, about quarter height of pedicle interarea. Costae on both valves, often sharply angular near umbo but becoming flattened anteriorly and broadening to about 1 mm wide at anterior border. They increase by division, number 13–15 in 10 mm, 10 mm from umbo; 10–12 in 10 mm, 30 mm from umbo; and 8–10 in 10 mm at anterior margin; and are superimposed on 3–4 low, rounded to sub-angular plications on each flank. Costae sub-equal and not arranged in fasciculae.

Interior of pedicle valve with thick, peg-like teeth projecting from thickened borders of delthyrium, and short thick dental lamellae. Muscle impressions

rounded-rhombic in outline, their centre level with the hinge line. Adductor impressions occupy median strip about quarter width of entire impression. Posterior margin of valve greatly thickened and supports interarea; small apical callosity.

Interior of brachial valve not seen.

Discussion

This species has been formerly ascribed to *Spirifer ravana* DIENER which it resembles in shape and in the plication of the shell. However DIENER's species is not well enough established to be used as a basis for comparison. DIENER (1897, p. 34) based his description on two pedicle valves which he considered to be closely related to *S. marcoui* WAAGEN and differing only in the concave area and plicate shell. The brachial valve and internal characters are entirely unknown. *Spirifer ambiensis* WAAGEN is a smaller species with a fasciculate sculpture.

Spirifer neomarcoui LICHAREW (1942, p. 65, pl. 2, fig. 1) was proposed for sharply plicated forms, otherwise identical with *S. marcoui* WAAGEN. It appears to have sharper plications than *Spirifer striato-plicatus* sp. nov. and a sharper sulcus and fold, although LICHAREW states that these characters are variable.

Spirifer kaninensis LICHAREW (1943, p. 284, figs. 1–4) resembles the present species in general appearance and in its internal characters. It is, however, a more transverse form with less convex valves and a shallower, broader sulcus and fold. The plicae are weak and number two, rarely three, on each flank.

All the species mentioned above appear to be variable, at least in external form and sculpture, and the complete details of internal characters remain unknown. Thus the arctic forms may be related to the Asiatic ones or may be homoeomorphs. The Spitsbergen shells are provisionally treated as distinct although further work may show that they belong to a previously described species.

Occurrence

Spirifer Limestone of Svalbard. Spitsbergen, Tempelfjorden, Bjonahamna (S. M. E 18583–94); west of Kapp Schoultz (S. M. E 18209); Rejmyrefjellet (S. M. E 18328); Bünsow Land, Gipshuken (S. M. E 17539–42, E 17544); Tyrrellfjellet (S. M. E 17640, E 18688–9). Bjørnøya, Miseryfjellet (S. M. E 18350).

Spirifer cf. *poststriatus* NIKITIN

Plate 18, figs. 3–5. Text fig. 20

Cf. 1890 *Spirifer poststriatus* NIKITIN, pl. 2, fig. 16, (reproduced in LICHAREW 1938, pl. 23, fig. 9).
Cf. 1902 *Spirifer cameratus* TSCHERNYSCHEW, (not MORTON), part, pl. 5, figs. 3–5.
Cf. 1939 *Spirifer poststriatus* LICHAREW and EINOR, p. 210, pl. 16, fig. 8.

Description

Medium sized *Spirifer* with sub-pentagonal to trapezoidal outline, sometimes transversely extended. Valves equally convex. Greatest width at or slightly anterior to hinge line. Cardinal extremities rounded. Growth lines show that young individuals are transversely extended and that later growth is directed largely

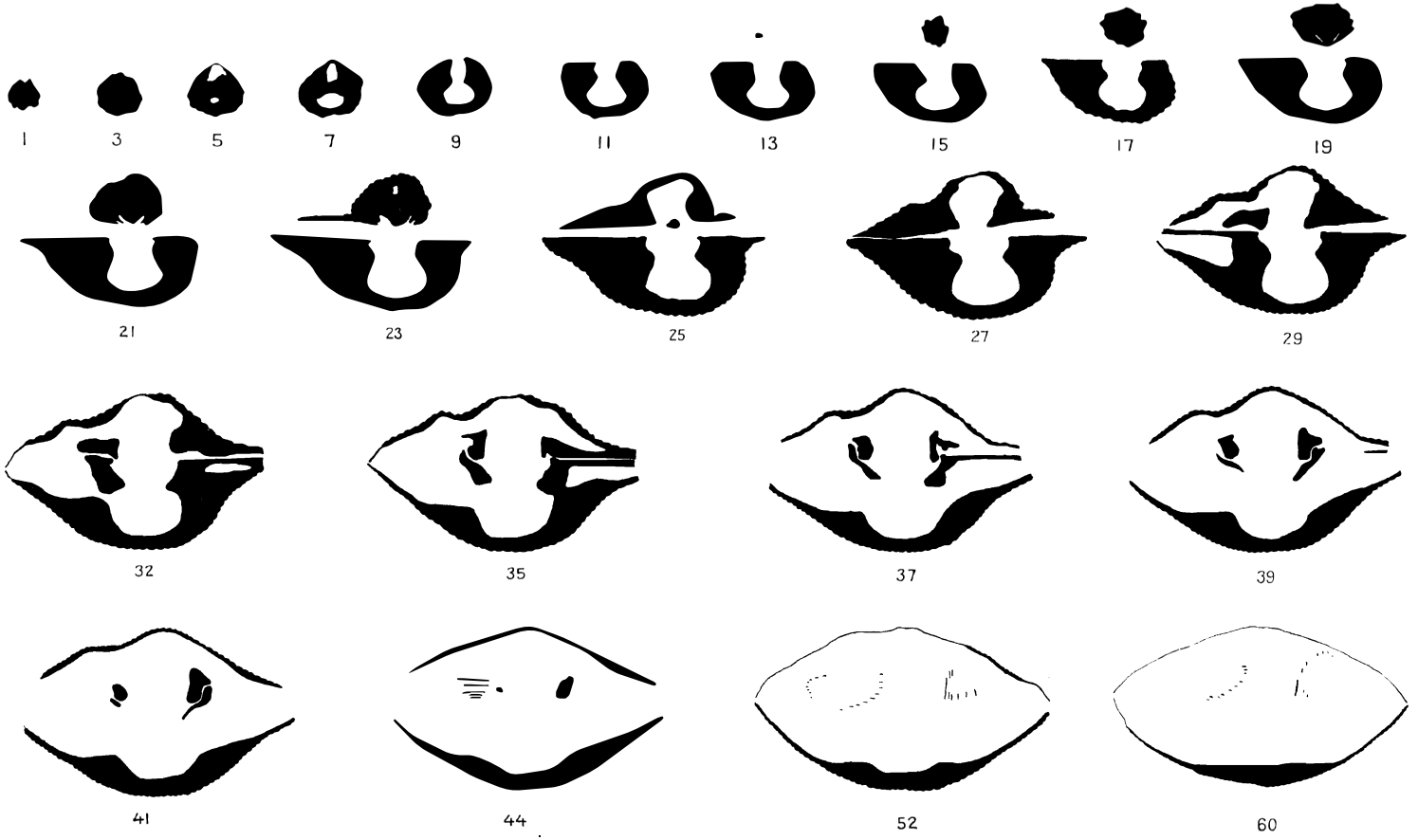

Fig. 20. *Spirifer* cf. *poststriatus* NIKITIN. Transverse sections of S.M. E 18017, × 1. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

anteriorly. Pedicle valve has small, obtusely pointed umbo, slightly overarching apsacline interarea; and shallow median sulcus, broadening anteriorly. Brachial valve has anacline interarea and low, rounded fold. Anterior commissure with single, low, rounded plica or almost rectimarginate.

Sculpture of costae which bifurcate about 5 mm from umbo and generally divide again about 15 mm from umbo but do not form fasciculae. Costae, angular on umbo, low and rounded on rest of valve. In 10 mm they number 12–14 on umbo, 8–10 in centre of valve and 5–6 at anterior border.

Internal characters known from serial sections (see text figure 20). Both valves show slight apical callosities and cardinal areas are considerably thickened. Teeth large, but delthyrial supporting lamellae and septa absent. Pedicle valve thickened ventrally and muscle field deeply impressed.

Discussion

The small number of specimens of this form show a considerable variation in outline. *S. poststriatus* NIKITIN also seems to be a variable species. TSCHERNYSCHEW included it in *S. cameratus*, along with other forms which are probably not conspecific. *S. cameratus* MORTON occurs in the Lower Pennsylvanian of North America. It has a narrower umbo and a more fasciculate sculpture than the Euro-Asian forms. Later authors (STEPANOV 1937b, p. 10, LICHAREW and EINOR 1939, p. 210) separated TSCHERNYSCHEW's form as *S. poststriatus* and varieties of this species.

Occurrence

Spirifer Limestone, Mertonberget, Ny Friesland (S. M. E 18013–7); Scree, Mertonberget (S. M. E 17991).

Spirifer? cf. *osborni* HARKER
Plate 18, fig. 6

Cf. 1960 *Spirifer osborni* HARKER, p. 65, pl. 20, figs. 15–17.

Two pedicle valves from the Brachipod Chert of Bellsund resemble *S. osborni* HARKER but are larger. The maximum width across the middle of the valve is 100 mm in one specimen and 80 mm in the second. The plicae are similar in form to those of *osborni* but coarser, four in 10 mm at mid-length. They also tend to divide unequally near the anterior border. The concave pedicle interarea is triangular with a maximum height of about 12 mm.

R. M. S. Br. 878, Bellsund.

B. M. no number, Akseløya, Bellsund, coll. E. GARWOOD.

Genus *Neospirifer* FREDERICKS, 1919

Diagnosis

Shells differing from *Spirifer* only in having the costae fasciculate.

Genotype: *Spirifer fasciger* KEYSERLING.

Discussion

This genus has not been clearly defined and different authors have used it in different senses, often including forms with costate and plicate shells here retained in *Spirifer*. The status of *Neospirifer* has been discussed by LICHAREW (1942, p. 64–66).

Neospirifer cf. *fasciger* (KEYSERLING)
Plate 18, figs. 7–8

Cf. 1846 *Spirifer fasciger* KEYSERLING, p. 231, pl. 8, figs. 3–3b.
Cf. 1902 *Spirifer fasciger* TSCHERNYSCHEW, p. 141, part, pl. 49, fig. 1.
? 1914 *Spirifer fasciger* WIMAN, p. 41, part, pl. 5, figs. 14–16.
1937a *Spirifer moosakhailensis* STEPANOV, (not DAVIDSON), p. 140, pl. 7, figs. 1–2.

Description

Shell transversely elongated, with greatest width slightly anterior to hinge line. Cardinal extremities rounded and lateral and anterior borders form a regular curve. Valves equally convex. Anterior commissure uniplicate. Pedicle valve with well-defined sub-angular sulcus, broadening and deepening anteriorly. Interarea linear, slightly concave, and apsacline. Umbo small. Brachial valve with low rounded fold and low concave anacline interarea about a third as high as the pedicle interarea.

Sculpture of fine sub-angular plicae, preserved in detail on internal moulds, and arranged in fasciculae, six on each side of mid-line. Plicae originate at umbo, split into three, 5–10 mm from umbo and again divide 20–25 mm from umbo. Sulcus contains unbranched median plica and lateral plicae arising from fasciculae bounding sulcus. Muscle field in pedicle valve sub-circular in outline. Other internal characters not seen.

Discussion

N. fasciger has been used broadly to include many *Spirifer* species with fasciculate costae or simple costae superimposed on plicae. Keyserling in his original description stated that a deep sulcus and fold was present and that there were three broad major plicae, flanked with small, sharp, unequal plicae, rapidly increasing in number by insertion.

Spirifer moosakhailensis DAVIDSON has often been confused with *N. fasciger*. The lectotype of the Indian species (DAVIDSON, 1862, pl. 2, figs. 2a–c) clearly shows a sculpture of simple costae superimposed on rounded radial folds. However, *Spirifer* species of this type show a great variation of form (see LICHAREW 1942) and are not easily defined.

Occurrence

Spirifer Limestone of Bjørnøya, west point of Lundenaeringane (S. M. E 17919); Miseryfjellet (S. M. E 17944). Brachiopod Chert of Ny Friesland, Komarovfjellet (S. M. E 18387).

Neospirifer sub-fasciger? LICHAREW 1934
Plate 17, figs. 10–11

1914 *Spirifer fasciger* WIMAN, (not KEYSERLING), p. 41, part, pl. 5, figs. 6–13 only.

A single pedicle valve and the internal mould of a brachial valve are conspecific with WIMAN's figured specimens. This form differs from *N. fasciger* KEYSERLING in its smaller size and trapezoidal outline. The sulcus and fold are sharply angular and the fine plicae form a pattern similar to that of *N. fasciger*.

WIMAN's figured specimens were included by LICHAREW (1934 p. 62) in *N. sub-fasciger* var. *longa*. However, it is doubtful whether LICHAREW's specimens, from the River Kolyma in north-east Siberia, are conspecific with WIMAN's. BRANSON (1948, p. 431) stated that YANISCHEVSKY (1938) showed LICHAREW's locality to be in Tournaisian rocks. However KASCHIRZEV (1959, p. 58) recorded *N. subfasciger* LICHAREW from the upper part of the Tompinsk Series (top of the Lower Permian) and from the Upper Permian of the Yano-Kolymsk folded zone of north-east Siberia. However, the specimens he figured are larger and have a greater number of plicae than the Svalbard specimens.

The specimens described as *S. sub-fasciger* by STEPANOV (1937a, p. 139, pl. 7, figs. 4a–b), are too poorly figured for comparison. They were collected from the Lower Brachiopod Chert at Kapp Starostin, Isfjorden, higher in the succession than either WIMAN's or the present specimens.

Occurrence

Cora Limestone, Bjørnøya (WIMAN 1914).

Upper Wordiekammen Limestone, Gipsvika (S. M. E 18772); Tyrrellfjellet (S. M. E 18271).

Neospirifer cf. *tegulatus* (TRAUTSCHOLD)
Plate 18, fig. 9; plate 19, fig. 1

Cf. 1876 *Spirifer tegulatus* TRAUTSCHOLD, p. 354, pl. 35, figs. 6a–g.
Cf. 1937 *Neospirifer tegulatus* IVANOV and IVANOVA, p. 30, 188, pl. 2, figs. 1–4.
Cf. 1952 *Neospirifer tegulatus* SARYCHEVA and SOKOLSKAYA, p. 192, pl. 54, No. 309.

Description

Outline sub-hexagonal to rounded rectangular, greatest width anterior to hinge line. Sulcus and fold low and rounded. Umbones almost equal in size but pedicle umbo narrower and more convex. Pedicle interarea concave apsacline; brachial interarea flat, orthocline; interareas sub-equal in size. Sculpture of fine, fasciculate plicae. Shell coarsely recrystallized but traces of imbricating growth lamellae, characteristic of *N. tegulatus*.

This species is represented by three specimens (P.M.O. A 26292–3, A 26296), collected from the Upper Cyathophyllum Limestone of Skedvifjella, Von Postbreen. They are internal moulds with the shell present on the umbonal areas.

Genus *Brachythyrina* FREDERICKS, 1929

1919 *Elina* FREDERICKS, p. 321, not HOULBERT, 1918 (INS.)
1925 *Anelasma* IVANOV, p. 109, not DARWIN, 1851 (CRUST.)
1926b *Elina* FREDERICKS, p. 399, not HOULBERT, 1918.
1929 *Brachythyrina* FREDERICKS, p. 103.

Diagnosis

Spiriferids sculptured with relatively broad, low, rounded plicae, increasing in width anteriorly and rarely bifurcating. Hinge line extended and interareas rectangular. Dental lamellae present.

Genotype: *Spirifer strangwaysi* VERNEUIL.

Discussion

This genus is similar internally to *Brachythyris* M'COY but is distinguished by the extended hinge line and rectangular interareas.

There appear to be no grounds for separating forms like *Spirifer rectangulatus* KUTORGA which FREDERICKS made the genotype of *Elina*.

Brachythyrina arctica sp. nov.
Plate 17, figs. 12–16

1917 *Spirifer rectangulatus* var. *alta* GRÖNWALL, p. 571, part, pl. 28, figs. 1–5.
1950 *Spirifer* cf. *rectangulatus* FREBOLD, p. 62, pl. 5, fig. 7.

Type data

Holotype: X 632.1.

Paratypes: X 632.2–.23.

Type locality: Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land, Spitsbergen.

Description

Medium sized, hinge line up to 50 mm long. Outline variable, sub-pentagonal or sub-rectangular, more or less transversely extended. Pedicle valve moderately convex, with narrow median sulcus, broadening only slightly towards anterior border. Brachial valve equally convex with narrow median fold. Interareas low, rectangular, marked with growth lirae and prominent longitudinal grooves. Brachial interarea flat, orthocline, about quarter height of gently concave, apsacline, pedicle interarea. Anterior commissure uniplicate.

Plicae 0.5–1.0 mm wide on umbo, broadening to 3–4 mm at anterior margin, separated by inter-plical sulci normally narrower than plicae. Sulcus contains median plica and two flanking plicae which arise on the umbo from first lateral plicae. Brachial fold consists of single large plica which divides in some specimens to form two smaller flanking plicae. Lateral plicae number nine on each side and do not divide. Growth lines prominent especially near anterior border.

Valves relatively thick. Interior of pedicle valve has low, rounded median ridge in apical region. Delthyrial supporting plates absent. Pedicle valve muscle field elongate oval in outline.

Discussion

This species resembles *B. rectangula* (KUTORGA) but it is smaller and has a narrower sulcus and fold. The specimens from Holms Land, described by GRÖNWALL and FREBOLD (see synonymy) which are preserved in the Mineralogical Museum, Copenhagen, appear to be conspecific with *Brachythyrina arctica* sp. nov. GRÖNWALL's name *alta* is a homonym of *Spirifer alta* HALL 1867. One of GRÖNWALL's specimens (p. 28, fig. 6) is a *Choristites*.

Occurrence

Lower Marine Series, Holms Land, north-east Greenland. Tårnkanten Sandstone, Spitsbergen, Oscar II Land, Tårnkanten (X 608.1–.8); Jutulslottet (X 614.1–.2, X 619.1–.4, S. M. E 18831–3); Robertsonfjellet (X 632.1–.23). Ambigua Limestone, Kobbebukta, Bjørnøya (S. M. ? E 18445).

Genus *Licharewia* EINOR, 1939

1939 *Licharewia* EINOR, p. 132.
1952 *Rugulatia* SOKOLSKAYA, p. 175.
1960 *Licharewia* SLUSAREVA, p. 41.

Diagnosis

Shell normally extended transversely. Sulcus and fold rounded, normally smooth, but may have up to four weak plicae. Lateral areas of both valves with broad, weakly convex, simple plicae, separated by narrow interplical sulci. Pedicle valve with thick dental lamellae joined to floor of valve by adminiculae. Apical callosity fused with delthyrial plate and posterior parts of dental lamellae.

Genotype: *Spirifer stuckenbergi* NETSCHAJEW.

Discussion

The diagnosis of *Rugulatia* given by SOKOLSKAYA is the same in detail as that given for *Licharewia* by EINOR.

SOKOLSKAYA proposed *S. rugulatus* KUTORGA as the genotype. This species was explicitly included by EINOR in *Licharewia*. *Licharewia* was described in detail, in Russian, by SLUSAREVA (1960).

Licharewia spitsbergiana sp. nov.
Plate 19, figs. 2–6. Text fig. 21

?1939 *Spirifer* cf. *lahuseni* LICHAREW and EINOR, p. 103, pl. 18, figs. 5–6.

Type data

Holotype: S. M. E 18004.

Paratypes: S. M. E 18003, E 18005–12.

Type locality: Spirifer Limestone, Mertonberget, Chydeniusbreen, Ny Friesland, Spitsbergen.

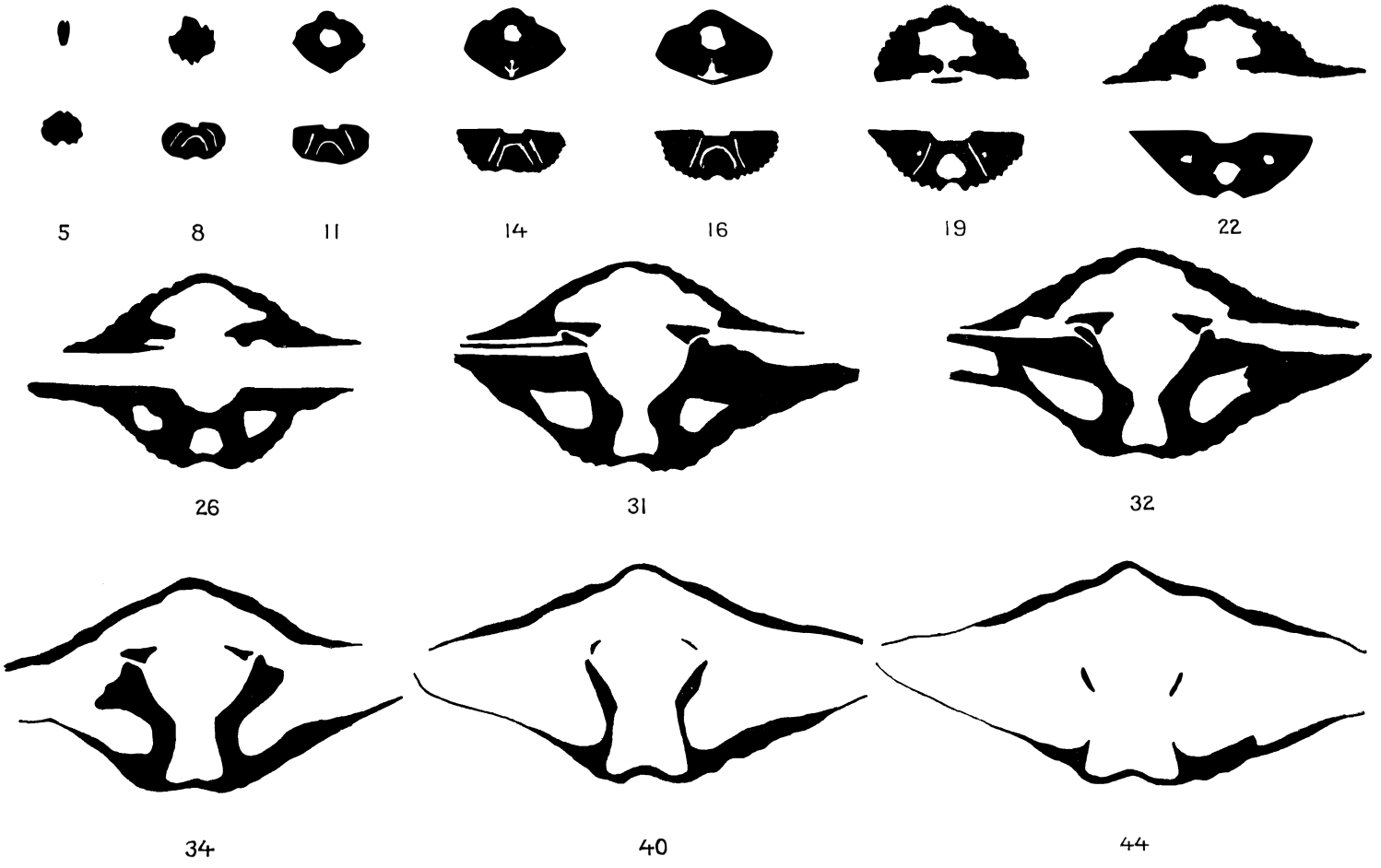

Fig. 21. *Licharewia spitsbergiana* sp. nov. Transverse sections of paratype, S.M. E 18009, × 1. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

Diagnosis

Large, transversely extended *Licharewia* with smooth sulcus and fold, and rounded cardinal extremities. Valves with 10–13 plicae on each side of the mid-line.

Description

Outline trapezoidal, moderately to strongly transversely extended. Cardinal extremities broadly rounded to subacuminate and greatest width immediately anterior to hinge line. Valves moderately and equally convex. Anterior commissure strongly uniplicate. Pedicle valve with moderately deep, smooth, rounded sulcus widening anteriorly to about quarter width of valve. Pedicle interarea broadly triangular, gently concave, apsacline and about 10 mm high in mid-line. Delthyrium forms equiangular triangle. Brachial valve with smooth, flattened fold, narrow on umbo but rapidly broadening anteriorly. Brachial interarea very low, orthocline.

Lateral plicae simple, low, rounded, numbering 10–13, less than 0.5 mm wide on umbo increasing to 5 mm at anterior margin; interplical sulci narrow.

Internal characters known from serial sections (see text figure 21). Pedicle valve interior has strong dental lamellae fused, in apical part of valve, with transverse delthyrial plate, converging anteriorly and joined by adminiculae to floor of valve. Muscle field broad, with trilobed anterior margin. Brachial valve interior with low median ridge, appearing on internal mould as narrow groove along centre of fold.

Discussion

Licharewia spitsbergiana sp. nov. appears to have close affinities with both *L. stuckenbergi* (NETSCHAJEW) and *L. lahuseni* (NETSCHAJEW). It differs from the former in having a broader sulcus and fold, and from both of NETSCHAJEW's species in the coarser and less numerous plicae. It is possibly conspecific with *L. neosibirica* EINOR, as figured by KASCHIRZEV (1959, pl. 27, figs. 1–3).

Occurrence

Only known from the type locality. The specimens described by LICHAREW and EINOR (see synonymy) were from the Permian of Borzov Bay on the west coast of Novaya Zemlya. *Licharewia* occurs on the Russian Platform in Lower Kazanian deposits.

Licharewia wimani nom. nov.

1901 *Spirifer rugulatus arctica* FRECH, (not HAUGHTON, 1858), p. 498, pl. 63, fig. 4.
1914 *Spirifer loveni* WIMAN, (not DIENER, 1899), p. 50, pl. 7, figs. 12–13, pl. 8, figs. 1–4.

Type data

Lectotype (here selected): the specimen figured by WIMAN, 1914, pl. 7, figs. 12–13, pl. 8, fig. 3.

Type locality: Spirifer Limestone, Lovénberget, Ny Friesland, Spitsbergen.

Description

There is one pedicle valve in the Sedgwick Museum, and the following description is taken partly from this and partly from WIMAN's figured specimens.

Large, transversely extended, with greatest width, at hinge line, up to 120 mm. Pedicle valve moderately convex with interarea high, rectangular, slightly concave, and apsacline. Outline of delthyrium forms equilateral triangle. Apical angle 150°. Umbo broad and low, slightly overarching interarea. Median sulcus flat-bottomed, broadening anteriorly. Brachial valve with broad, low fold, triangular in outline. Sulcus and fold smooth, lateral plicae simple, numbering about 15, 1 mm wide near umbo, broadening anteriorly to 4 mm at anterior margin. Anterior commissure gently parasulcate.

Interior of pedicle valve with thick transverse delthyrial plate and dental lamellae joined posteriorly to floor of valve by adminiculae. Muscle field large, sub-circular in outline. Interior of brachial valve not known.

Discussion

Spirifer lovéni shows the characters of the genus *Licharewia* although some specimens in the Riksmuseum, Stockholm, labelled by WIMAN as *S. lovéni* (e.g. Br. 834) have a catacline pedicle interarea with smaller apical and delthyrial angles and are finely punctate. These are probably conspecific with *Pseudosyringothyris borealis* sp. nov.

Licharewia wimani nom. nov. differs from most other *Licharewia* species in its large size, large apical angle and moderately convex pedicle valve with more erect umbo.

Occurrence

WIMAN recorded this species from the Spirifer Limestone of Angelinberget, Nordaustlandet, and Stenbrohultdalen, Grønfjorden, as well as from the type locality.

The specimen in the Sedgwick Museum (S. M. E 17990) is from the Brachiopod Chert of Mertonberget, Chydeniusbreen, Ny Friesland.

Licharewia cf. *grewingki* (NETSCHAJEW)
Plate 19, figs. 7–9

Cf. 1911 *Spirifer grewingki* NETSCHAJEW, p. 81, 149, pl. 10, figs. 1a–d.
Cf. 1939 *Spirifer* (*Licharewia*) *grewingki* EINOR, p. 71, pl. 11, figs. 4–5.

Three alate pedicle valves with pointed cardinal extremities and a narrower sulcus than that of *L. spitsbergiana* resemble *L. grewingki* (NETSCH.). However, the lateral plicae number 10–12 whereas those of *L. grewingki* reach 25.

Occurrence

Middle Brachiopod Chert, Gipshuken (S. M. E 18266, E 18795); scree *ex* ? Brachiopod Chert, Cepheusfjellet, Polarisbreen (S. M. E 18061).

Genus *Choristites* Fischer de Waldheim, 1825

1825 *Choristites* Fischer de Waldheim, p. 7, pl. 1, figs. 1–4.
1919 *Munella* Fredericks, (not Bonnier 1896), p. 314.
1936 *Choristites* Miloradovich, p. 52.
1944 *Purdonella* Reed, p. 218.
1955 *Choristites* Dunbar, p. 157.

Diagnosis

Spiriferids with a sub-circular or sub-elliptical outline, low pedicle sulcus and brachial fold. Sculpture of low, rounded costae. Pedicle valve has thick delthyrial supporting lamellae, joined to long, subparallel adminiculae which extend forward into the muscle field.

Genotype: *Choristites mosquensis* Fischer.

Discussion

Reed proposed *Purdonella* as a new name for the junior homonym *Munella* Fredericks (genotype *Spirifer nikitini* Tschernyschew). However, there is no basis for a generic distinction between *Munella* and *Choristites* (see Licharew 1934 b, p. 443 and Miloradovich 1936, p. 13, 52).

Choristites aliforme sp. nov.
Plate 20, figs. 1–3

?1911 *Spirifer mosquensis* Holtedahl, (not Fischer), p. 22, pl. 4, figs. 1–2.
1917 *Spirifer supramosquensis* Grönwall, (not Nikitin), p. 565, pl. 27, figs. 14–16.
?1917 *Spirifer fulmari* Grönwall, p. 569, pl. 27, figs. 17–19.
1917 *Spirifer rectangulus* var. *alta* Grönwall, p. 571, part, pl. 28, fig. 6.
1950 *Spirifer* (*Choristites*) cf. *fritschi* Frebold, p. 63, pl. 5, figs. 1, 2, 4–6, 8.
1950 *Spirifer* (*Choristites*) *fulmari* Frebold, not Grönwall, p. 66, pl. 5, fig. 3.

Type data

Holotype: S. M. E 18108.
Paratypes: S. M. E 18105, E 18107, E 18109–10.
Type locality: Scree, *ex* Passage Beds, north-east shore of Adolfbukta, Billefjorden.

Diagnosis

Choristites of medium size, hinge forming greatest width of the shell. Cardinal extremities pointed and extended to form flattened ears. Sulcus groove-like.

Description

Outline semi-circular. Pedicle valve moderately convex, with narrow umbo over-arching interarea. Latter rectangular, concave apsacline and marked by vertical striations. Hinge line extended laterally to form greatest width of shell. Cardinal extremities acutely pointed but rarely preserved. Ears large and flattened. Sulcus narrow and groove-like but broadening slightly anteriorly. Costae broad and flat, 1.0 mm to 1.5 mm in width, increasing by bifurcation, and numbering

about 25 on each side of sulcus. Growth lines prominent on ears. Brachial valve represented by one internal mould. This has a broad, low, median fold. Adminiculae in pedicle valve extend 30 mm anterior to umbo.

Discussion

This form is described as a new species at the risk of making a synonym. HOLTEDAHL described a *Choristites* from the Scheteligfjellet Beds, as *Spirifer mosquensis*. He figured two specimens, one of which is a fairly complete pedicle valve showing a narrow sulcus but in which the ears are obscured. The hinge on the right side of the umbo appears to be extended. These specimens are not conspecific with *C. mosquensis* FISCHER, and FREDERICKS (1926 a, p. 254) renamed them *C. holtedahli*. Unfortunately they are not well enough preserved to be used as a basis for comparison.

WIMAN (1914, p. 47, pl. 7, figs. 1–4) described a form from the Ambigua Limestone of Bjørnøya as *Spirifer supramosquensis* NIKITIN. His figured specimen is only 18 mm in width and may be a juvenile specimen of *Choristites aliforme* sp. nov. to which I tentatively refer specimens from the Ambigua Limestone in the Sedgwick Museum.

The specimens described by GRÖNWALL (1917) and FREBOLD (1950) are from the Lower Marine Series of north-east Greenland. None of the figured specimens are complete but that figured by FREBOLD (pl. 5, fig. 6) shows an extended hinge line and flattened ears as well as a narrow groove-like sulcus. The *Choristites* from north-east Greenland in the Mineralogical Museum, Copenhagen, can probably all be referred to one species. *Spirifer fulmari* GRÖNWALL is represented by a single specimen distinguished by a finer and distorted costation. However, the width of the costae vary in other specimens, named *S. mosquensis* by GRÖNWALL and *S.* cf. *fritschi* by FREBOLD. GRÖNWALL himself (1917, p. 569) suggested that the distortion of the costae of *fulmari* was due to damage during growth. If these arctic *Choristites* may be included in one species, the name *fulmari* has priority.

Both *Munella amalitzkii* FREDERICKS (1927, p. 8, figs. 6–11) and *Choristites miloradovichi* EINOR (1939, p. 121, 214, pl. 20, fig. 1, pl. 21, figs. 1a–c) are similar to *Choristites aliforme* sp. nov. but none of the figured specimens have such well developed ears as the Spitsbergen form.

Occurrence

Lower Marine Series, Holms and Amdrups Land, north-east Greenland. Passage Beds, Spitsbergen, Billefjorden, North-east shore Adolfbukta, (S. M. E 18108–10); Rudmosepynten, (S. M. E 18102–7); Dickson Land, Trikolorfjellet (S. M. E 18872). Ambigua Limestone, Bjørnøya, point north of Kapp Kåre (S. M. E 17982–6). Specimens doubtfully referred to *Choristites aliforme* sp. nov. are from Passage Beds, Minkinfjellet (S. M. E 17182–91); Carboniferous, Pachtusovfjellet (S. M. 18859–60); Tårnkanten Sandstone, Jutulslottet (X 621 (13)).

Choristites sp.

?1902 *Spirifer* cf. *fritschi* TSCHERNYSCHEW, p. 543, pl. 13, figs. 1a–c.
?1914 *Spirifer fritschi* WIMAN, (not SCHELLWIEN 1892), p. 48.
?1932a *Munella uralica* FREDERICKS, (not LEBEDEW 1913), p. 184.
?1939 *Spirifer fritschi* var. *arctica* EINOR, (not HAUGHTON 1858), p. 87, pl. 14, figs. 3a–e.

Three incomplete pedicle valves of a large species of *Choristites* differ from *C. fritschi* SCHELLWIEN in more rounded outline and greater convexity. They cannot be identified with any certainty but are probably the forms included by WIMAN in *fritschi*. The closest comparison may be made with *C.* cf. *fritschi* TSCHERNYSCHEW which FREDERICKS renamed *Munella uralica*. The form from Novaya Zemlya described by EINOR (see synonymy) has a pentagonal outline and a uniplicate anterior commissure. The Spitsbergen form may also be compared with *C. cinctiformis* and *C. jijulensis* from the Moscow Basin.

Passage Beds, Minkinfjellet (S. M. E 17192); Jacksonfjellet (S. M. E 17198); Scree, Malte Brunfjellet (S. M. E 18815).

Genus *Spiriferella* TSCHERNYSCHEW, 1902, emend. MILORADOVICH, 1936.

1902 *Spiriferella* TSCHERNYSCHEW, p. 522.
1936 *Spiriferella* MILORADOVICH, p. 72.
1955 *Spiriferella* DUNBAR, p. 136.

Diagnosis

Spiriferids having the posterior part of the pedicle valve filled by secondary deposits of shell material which completely enclose the dental lamellae and fuse them with the solid apical region. Pedicle valve also thickened around the muscle impressions and without a median septum. Outline of shell and form of sulcus and fold highly variable. Sculpture of coarse plicae, simple or divided, of variable form and number. Shell surface granular.

Genotype: *Spirifer saranae* VERNEUIL.

Discussion

TSCHERNYSCHEW conceived *Spiriferella* as a subgenus of *Spiriferina* but, although the surface is granular, the shell is impunctate and is unrelated to *Spiriferina*. He thought a median septum was present in the pedicle valve, almost entirely buried in the thickened shell. FREDERICKS (1916, p. 7, 24) stated that the dental lamellae were joined to form a pseudospondylium and that a median septum (euseptum) was present. The apical region of *Spiriferella parryana* was sectioned by MILORADOVICH (1936, pl. 1, figs. 1–2, pl. 2, figs. 1–2) who showed that these structures were due to secondary recrystallization. These findings are fully supported by study of the present material. DUNBAR (1955) gives a full discussion of *Spiriferella*.

The variability of many *Spiriferella* species has resulted in the naming of supernumerary sub-species and varieties (e. g. GRABAU 1931, p. 128–168) and much confusion by later authors who have split or lumped these in different ways.

The inadequacy of early descriptions, often based on one or a small number of specimens not fully representative of the species, has added to the difficulties. The Svalbard specimens I have seen may be grouped into five species, three of which occur in the Spirifer Limestone. The latter may be divided into two species, *polaris* and *draschei*, with constant external characters and a third which displays such a great variation that no two specimens are alike. This third group is here referred to *keilhavii;* the extent of the variation is shown on plate 20.

Spiriferella cf. *saranae* (VERNEUIL)
Plate 20, figs. 11–12

Cf. 1845 *Spirifer saranae* VERNEUIL, p. 169, pl. 5, fig. 15.
Cf. 1846 *Spirifer saranae* KEYSERLING, p. 232, pl. 8, figs. 4–5, pl. 10, figs. 3a–d.

Description

Seven small convex pedicle valves with rounded pentagonal outline; length and width approximately equal. Narrow V-shaped sulcus flanked by six rounded plicae separated by narrow, more angular furrows. In one specimen the three distal plicae have a median groove.

Discussion

VERNEUIL figured one fragmentary specimen from Sarana on the river Ufa, south of Krasno-Ufimsk, an area which is now mapped as Sakmarian and Artinskian. KEYSERLING's figured specimens have a similar size and appearance to the Svalbard forms but are from the river Zoiva (C_2–P_1) and may not be conspecific with VERNEUIL's.

TSCHERNYSCHEW (1902, p. 522) had access to the older collections of KEYSERLING, MOELLER, STUCKENBERG and GRÜNEWALDT. However, he figured only two specimens, a pedicle valve (pl. 12, fig. 4), which *S. polaris* (WIMAN) closely resembles and a brachial valve (pl. 40, fig. 7), of a smaller specimen which has a low fold quite unlike the brachial valve of *polaris*. The specimens figured by TSCHERNYSCHEW and STEPANOV (1916, p. 50, pl. 9, fig. 1, pl. 11, fig. 1), and LICHAREW and EINOR (1939, p. 216, pl. 22, fig. 1) as *S. saranae* have a plicated and less angular sulcus. Those figured by FREBOLD (1937, p. 45, pl. 11, figs. 7–8) have a shallow, rounded sulcus and belong to *S. keilhavii*.

Occurrence

Cora Limestone, Ymerdalen, Bjørnøya (S. M. E 17975–7). WIMAN records specimens from this locality as *S. polaris*.

Spiriferella polaris (WIMAN)

1914 *Spiriferina polaris* WIMAN, p. 39, pl. 4, figs. 1–25, pl. 5, figs. 1–5.
1936 *Spiriferella polaris* STEPANOV, p. 123.
1937a *Spiriferella polaris* STEPANOV, p. 150, pl. 8, figs. 5–8.
1937 *Spiriferella polaris* FREBOLD, p. 47, pl. 11, figs. 1, 1a–b.
1958 *Spiriferella polaris* FORBES, p. 475.

Type data

Lectotype (here selected): the specimen figured by WIMAN, 1914, pl. 4, figs. 23–25.

Type locality: Spirifer Limestone, Bjonahamna, Tempelfjorden, Spitsbergen.

Diagnosis

Spiriferella with deep non-plicated V-shaped pedicle sulcus and high, angular brachial fold, making brachial valve highly convex. Lateral plicae simple.

Description

Shell longer than broad, hinge line shorter than greatest width. Both valves strongly convex. Pedicle valve thick, with deep V-shaped sulcus; umbo broad, pointed at tip, overarching moderately high, triangular, concave interarea. Deltidial plate triangular, with concave anterior margin, and raised above surface of interarea. Brachial valve relatively thin, with high V-shaped fold, narrow umbo and low, orthocline interarea. Anterior commissure strongly and sharply plicated.

Valves sculptured with broad plicae, rounded with narrow interplical sulci on pedicle valve, more angular with broader interplical sulci on brachial valve; numbering 5–7, usually six, on each side of mid-line. Flanks of sulcus and fold not plicated. Both valves covered with fine reticulum of longitudinal lirae and growth lines, bearing granule at each intersection and forming irregular pattern. Fine sculpture sometimes retained on silicified shells.

Interior of pedicle valve with stout hinge teeth. Dental lamellae and adminiculae fused with secondary shell material filling apical region. Muscle field lanceolate-oval in outline; adductor impressions longitudinally ridged and lie on narrow raised median ridge, about quarter maximum width of muscle field. Divaricator impressions marked with low, obscure ridges radiating from centre of muscle field. Interior of brachial valve not seen.

Discussion

S. polaris is distinguished from *saranae* by the extreme development of the sulcus and fold, and, according to WIMAN, by the more rounded muscle field.

The specimens figured by LICHAREW and EINOR as *S. saranae polaris* (1939, pl. 22, figs. 2–3) are not conspecific with *S. polaris*.

Occurrence

Common in the Lower Brachiopod Chert of Spitsbergen. The specimens described here are from: Spirifer Limestone, Bünsow Land, Tyrrellfjellet (S. M. E 17114–5, E 17643–7, E 18686); Gipshuken (S. M. E 17565–8, E 17598–604); Bjonahamna (S. M. E 18615–7); Wardropfjellet (S. M. E 18275); Billefjorden, Skansbukta (S. M. E 18319, E 18417–20); Lower Brachiopod Chert, Oslobreen, Komarovfjellet (S. M. E 18385); station G 859 (S. M. E 18156); Bünsow Land, Templet (S. M. E 17470, E 18668–70); Scree *ex* Lower Brachiopod Chert, Barkowfjellet (S. M. E 18360); Brucebreen (S. M. E 18381).

Spiriferella keilhavii (VON BUCH)
Plate 20, figs. 8–10

1847 *Spirifer keilhavii* VON BUCH, p. 10, figs. 2a–b.
1855 *Spirifer keilhavii* SALTER, p. 386, pl. 36, figs. 9–11.
1858 *Spirifer arcticus* HAUGHTON, p. 243, pl. 9, fig. 1.
1874 *Spirifer wilczeki* TOULA, p. 271, pl. 1, figs. 3a–b.
1875c *Spirifer parryana* TOULA, (not HALL 1858), p. 256, pl. 7, figs. 7, 8a–c.
1901 *Spirifer keilhavii* FRECH, pl. 57c, figs. 1b–c.
1902 *Spiriferina* (*Spiriferella*) *keilhavii* TSCHERNYSCHEW, p. 527, pl. 40, figs. 1–4.
1902 *Spiriferina* (*Spiriferella*) *salteri* TSCHERNYSCHEW, p. 528, pl. 6, fig. 5, pl. 12, figs. 5–6.
1914 *Spiriferina keilhavii* WIMAN, p. 36, pl. 2, figs. 25–30, pl. 3, fig. 1.
1914 *Spiriferina draschei* WIMAN, p. 38, part, pl. 3, fig. 2.
1931 *Spiriferella parryana* FREBOLD, p. 18, pl. 5, figs. 5–6.
1931 *Spirifer rectangulus* FREBOLD, (not KUTORGA), p. 27, pl. 5, figs. 2, 10.
1931 *Spirifer interplicata* var. *bashkirica* FREBOLD, (not TSCHERNYSCHEW), p. 27, pl. 5, figs. 3–4.
1931 *Spiriferella keilhavii* FREBOLD, p. 28, pl. 5, figs. 7–9.
1936 *Spiriferella keilhavii* STEPANOV, p. 123, pl. 5, figs. 2–3.
1937a *Spiriferella keilhavii s. l.* STEPANOV, p. 143, pl. 7, figs. 8–11.
1937 *Spiriferella parryana* FREBOLD, p. 45, pl. 11, fig. 6.
1937 *Spiriferella saranae* FREBOLD, (not VERNEUIL), p. 45, pl. 11, figs. 7–8.
1937 *Spiriferella keilhavii* FREBOLD, p. 46, pl. 11, fig. 9.
1939 *Spiriferella saranae s. l.* LICHAREW and EINOR, (not VERNEUIL), p. 131, pl. 22, figs. 1–7, pl. 23, figs. 1–5.
1939 *Spiriferella keilhavii s. l.* LICHAREW and EINOR, p. 139, pl. 23, figs. 6–7, pl. 24, figs. 1–9.
1955 *Spiriferella keilhavii* DUNBAR, p. 139, pl. 25, figs. 1–9, pl. 26, figs. 1–11, pl. 27, figs. 1–14.
1958 *Spiriferella keilhavii* FORBES, p. 475.
1958 *Spiriferella parryana* FORBES, p. 475.
1960 *Spiriferella keilhavii* HARKER, p. 72, part, pl. 22, figs. 9–11.

Type data

Lectotype: VON BUCH's original figure is a drawing constructed from several specimens, two of which are figured by FRECH 1901. LICHAREW and EINOR (1939, p. 218) argued that, since VON BUCH noted the presence of divided plicae in his original description, the specimen figured by FRECH, (pl. 57 c, fig. 1 b), should be regarded as the lectotype.

Type locality: Spirifer Limestone, Miseryfjellet, Bjørnøya.

Diagnosis

Form variable but usually the valves have a lower convexity than in other species and the hinge line equals the greatest width of the shell. The pedicle sulcus is relatively shallow and normally plicate but wide or narrow, and rounded or V-shaped in section. The plicae are rounded or angular, simple or divided, but those on the pedicle valve are always broader than the interplical sulci. Brachial valve less convex or equal in convexity to the pedicle valve and has a low median fold.

Discussion

This extremely variable species has been given several names, distinctions being generally based on the form of the sulcus and the plicae. In a large collection

the various forms can be seen to grade into each other and must be grouped either as one species (DUNBAR 1955) or divided into a large number of varieties (GRABAU 1931, LICHAREW and EINOR 1939). GRABAU described a series of mutations based on division of the plicae. In cases where these forms appear to have no stratigraphical significance but occur together in the same beds, the former practice is to be recommended.

S. wilczeki (TOULA) and *S. parryana* (TOULA) were described from small collections; more collecting has shown these species to be end forms of two variations, *wilczeki* with divided plicae and a broad sulcus and *parryana* with simple plicae and a narrow sulcus. WIMAN recognized this and the present collections confirm it, some specimens being identical with TOULA's type material.

The type specimen of *S. arcticus* HAUGHTON may also be included in *S. keilhavii*. The MCCLINTOCK collection described by HAUGHTON contains three pedicle valves, two from Bathurst Island, and one from Melville Island. These all differ in division of the plicae, and form of the sulcus, but until more specimens are collected and the brachial valve, interior characters and range of variation are known, they cannot be distinguished from *S. keilhavii*. On the other hand, if one specimen is distinguished as *S. arctica,* the other two must be given separate names.

FREBOLD (1931) compared some of the forms of *keilhavii* with previously described spiriferid species basing his comparison on external characters only.

STEPANOV (1937 a, p. 179) accepted a broad definition of the species but retained *wilczeki* and *parryana* as varietal names.

Some of the *Spiriferella* species from Kong Oscar's Land and Axel Heiberg Island described by TSCHERNYSCHEW and STEPANOV (1916, p. 74–84) may belong to *S. keilhavii*. Those described as *saranae, keilhavii*, and *parryana* (pl. 11, figs. 1–4, pl. 12, figs. 1–3), all from Great Bear Cape, probably constitute one species which appears to differ from *keilhavii* in the elongated and more convex pedicle valve and the higher fold on the brachial valve. The pedicle valve from Kapp Jungersen, Amdrups Land, figured by FREBOLD (1950, pl. 6, figs. 1, 1 a) as *S. saranae* var. *arctica* is similar to these.

Occurrence

Spiriferella keilhavii, taken in a broad sense, has an extensive distribution in Permian deposits of the arctic regions. It has been recorded from Capes Loushkin, Krasnyj and Pavlov in the North Island and Cape Severnyj Gusinyj in the South Island of Novaya Zemlya; the Ural (Lower Permian); central east Greenland (Upper Permian); north east Greenland; Melville and Bathurst Islands; and Grinnell Peninsula, Devon Island (Assistance Formation).

In Svalbard it is abundant in the Spirifer Limestone and also occurs at a higher stratigraphic level in the Brachiopod Chert. The specimens in the Sedgwick Museum are from the following localities: Spirifer Limestone, Bjørnøya. Miseryfjellet (S. M. E 18070–1, E 18340–2); Spitsbergen, Oscar II Land, Skivefjellet (X 644, X 668); Bünsow Land, Tyrrellfjellet (S. M. E 17611–4, E 17641–2); Gipshuken (S. M. E 17543, E 17548–64, E 17576–80, E 17597); Templet (S. M.

E 17468–9); Bjonahamna (S. M. E 18602–14); Billefjorden, Skansbukta (S. M. E 18317–8, E 18320–1); Tempelfjorden, west of Kapp Schoultz (S. M. E 18214); Sassendalen (S. M. E 18327).

Middle Brachiopod Chert, Templet (S. M. E 17489–90).

Spiriferella draschei (TOULA)

Plate 20, fig. 7

1875c *Spirifer draschei* TOULA, p. 239, pl. 7, figs. 4a–c.
1914 *Spiriferina draschei* WIMAN, p. 38, part, pl. 3, figs. 9–10, 18–19.
1916 *Spiriferella draschei* TSCHERNYSCHEW and STEPANOV, p. 82, pl. 9, figs. 2a–b
1935 *Spiriferella draschei* MILORADOVICH, p. 129, pl. 4, fig. 9.
1937a *Spiriferella draschei* STEPANOV, p. 149, pl. 8, figs. 9–10.
1939 *Spiriferella rajah* var. *magna* LICHAREW and EINOR, p. 149, pl. 25, figs. 2a–b.
1939 *Spiriferella rajah* var. *saranaeformis* LICHAREW and EINOR, pl. 149, pl. 25, figs. 1a–b, 4.
1958 *Spiriferella draschei* FORBES, p. 475 (under Lower Brachiopod Chert Fauna).
1960 *Spirifer keilhavii* HARKER, p. 72, part, pl. 23, figs. 1–2.

Type data

Lectotype: The specimen figured by TOULA 1875 c, pl. 7, figs. 4a–c. This is preserved in the Naturhistorisches Museum, Vienna.

Type locality: Spirifer Limestone, either Akseløya or the shore opposite, on the north side of Bellsund.

Diagnosis

Elongate, triangular or quadrate in outline. Hinge line normally less than greatest width. Pedicle valve convex with steep lateral slopes. Sulcus broadly V-shaped, broadening anteriorly and bearing narrow, simple or divided plicae. Brachial valve flattened but with narrow angular fold, bearing narrow plicae on its flanks. Anterior commissure sharply plicated.

Discussion

Spiriferella draschei almost certainly has close affinities with *S. keilhavii* and the two species may be connected by transitional forms. This appears to be the case in arctic Canada. The specimens from the Grinnell Peninsula figured by SALTER (1855, pl. 36, figs. 9–10) and by HARKER (1960, pl. 23, figs. 1–2) show intermediate characters. HARKER included *draschei* in the synonymy of *keilhavii* but STEPANOV (1937 b, p. 30) treated it as a variety of *S. saranae*.

Of the various forms from the Jisu Honguer Limestone, Mongolia, described by GRABAU (1931, p. 128, pls. 19–23) as *S. salteri*, his mutations γ, and δ resemble *draschei*. GRABAU compares these forms with *S. salteri* TSCHERNYSCHEW and *S. draschei* WIMAN, naming them respectively *S. salteri* var. *typica* and *S. salteri* var. *wimanni*. However, these varieties are clearly closely related to GRABAU's mutations α and β which resemble *S. keilhavii* as described above. Some of the specimens figured by WIMAN as *S. draschei* differ markedly from TOULA's original specimen and are probably forms of *keilhavii*. LICHAREW and EINOR (1939, p. 145) put some of them into *S. keilhavii* var. *pseudodraschei*.

In Spitsbergen the diagnostic characters of *S. draschei* appear to be relatively constant and all the specimens here referred to the species compare closely with the lectotype.

Occurrence

This species has a distribution similar to that of *S. keilhavii*. Specimens in the Sedgwick Museum are from the Spirifer Limestone, Bünsow Land, Gipshuken (S. M. E 17547, E 17589–96); Bjonahamna (S. M. E 18600–1); the Brachiopod Chert, Chydeniusbreen, Mertonberget (S. M. E 18032); Bünsow Land, Templet (S. M. E 18228); Gerardfjella (S. M. E 18364); Oscar II Land, Skivefjellet (X 685.1); and the Middle Brachiopod Chert, Gipshuken (S. M. E 17654).

Spiriferella aff. *interplicata* (ROTHPLETZ 1892)

Plate 20, figs. 4–6

1914 *Spiriferina draschei* WIMAN (not TOULA), pl. 3, fig. 11.
?1936 *Spiriferella parryana* MILORADOVICH, (not TOULA), p. 73, pl. 1, figs. 1–3, pl. 4, figs. 1–9.
1958 *Spiriferella draschei* FORBES, p. 475 (under Middle Brachiopod Chert Fauna).

Diagnosis

Spiriferella with strongly convex pedicle valve and flattened brachial valve. Pedicle sulcus narrow, rounded in cross section and containing two low, rounded, simple plicae. Lateral plicae rounded, generally simple; interplical sulci in the pedicle valve equal or slightly less than width of plicae and, in brachial valve, wider than plicae.

Description

Outline sub-pentagonal, hinge line slightly less than greatest width. Pedicle valve considerably thickened and strongly convex with narrow, pointed umbo overarching interarea. Narrow median sulcus, widening slightly towards anterior border, rounded in cross section and containing two low, rounded plicae which arise about 5 mm from umbo. Lateral slopes steep but running continuously into small flattened ears. Pedicle interarea high, strongly concave, with wide triangular delthyrium, covered posteriorly by convex deltidial plate. Four broadly rounded lateral plicae on each side of sulcus, separated by rounded interplical sulci approximately equal to plicae in width. Some specimens show traces of fifth or sixth plica on ears. Plicae sometimes subangular or square in cross section and those bounding sulcus tend to be larger than the others and may become divided into two or three.

Brachial valve relatively thin and not often preserved. Slightly convex sub-semicircular in outline with small umbo and low interarea. Plicae consist of a narrow median pair, separated by a narrow interplical sulcus and four on each side of mid-line, separated by broad interplical sulci. Surface of shell covered with granules, not so regularly spaced and coarser than those of *S. polaris*, and has fine reticulum of longitudinal lirae and growth lines.

Interior of pedicle valve posterior to hinge line filled with secondary shell deposits. Muscle field broadly oval to narrowly trapezoidal in outline, anterior end always pointed. Adductor impressions lie on narrow raised median strip which simulates low median septum in some specimens.

Discussion

In external characters this species is similar to *Spirifer interplicatus* ROTHPLETZ, differing essentially in having a higher pedicle interarea. Unfortunately ROTHPLETZ (1892, pl. 9, fig. 6) figured only one specimen and did not describe the interior. This species could be another form of *S. keilhavii* or *S. draschei* but 56 specimens are constant in those characters which are most variable in other *Spiriferella* species, viz. the plicae and the form of the sulcus. Moreover it has been found only in the Middle Brachiopod Chert.

Occurrence

Common in the Middle Brachiopod Chert; Chydeniusbreen, Mertonberget (S. M. E 18033–4); Sassenfjorden, Rundodden (S. M. E 18293); Marmierfjellet (S. M. E 18453); Gipshuken (S. M. E 17737–46, E 18791–4); Templet (S. M. E 17491); Oscar II Land, Skivefjellet (X 649, X 652, X 661, X 685.2); Kongsfjorden, west of Thiisbukta (S. M. E 18081).

Genus *Paeckelmannella* LICHAREW, 1934

1934a *Paeckelmannella* LICHAREW, p. 212.

Diagnosis

Alate spiriferids with concave rectangular interareas. Median fold and sulcus, latter with narrow median plica. Lateral areas with simple radial plications. Delthyrial supporting lamellae joined by transverse delthyrial plate. Median septum and adminiculae in pedicle valve well-developed. Apical callosity in median and lateral chambers. Shell impunctate.

Genotype: *Spirifer dieneri* TSCHERNYSCHEW.

Discussion

LICHAREW stated (p. 212):

Paeckelmannella differs from *Tylothyris* by the presence of a delthyrial plate and by a different character of the apical callosity which in *Paeckelmannella* is connected with the delthyrial plate and dental plates and in *Tylothyris* with the dental plates and the bottom of the valve.

Paeckelmannella differs from *Pterospirifer* DUNBAR in possessing a pronounced median septum.

Paeckelmannella aff. *expansa* (TSCHERNYSCHEW, 1902)
Plate 21, figs. 1–3. Text fig. 22

1914 *Spiriferina expansa* WIMAN, p. 34, pl. 2, figs. 15–24.
1937 *Spiriferina* cf. *expansa* FREBOLD, p. 44.
1937a *Spiriferina* (*Punctospirifer?*) *wimani* STEPANOV, (not HAMLET 1928), p. 155, 181, pl. 8, figs. 15a–b.
?1939 *Spirifer* (*Paeckelmannella*) *expansus* var. *wimani*, LICHAREW and EINOR, p. 117, 213, pl. 20, figs. 4a–c.
1958 "*Spiriferina*" *expansa* FORBES, p. 475.

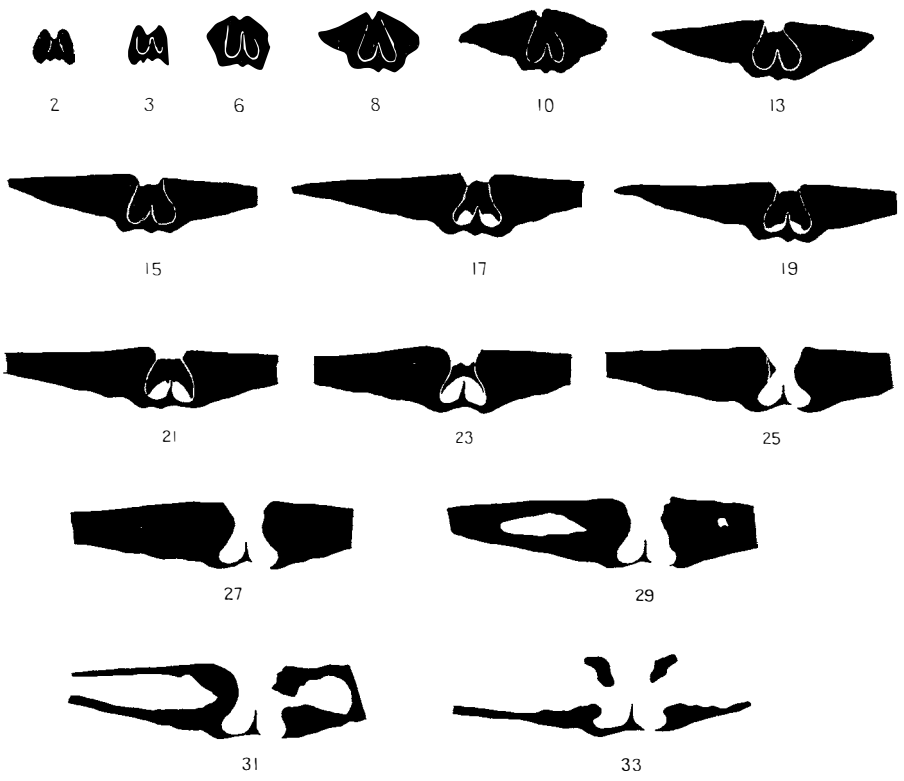

Fig. 22. *Paeckelmannella* aff. *expansa* (TSCHERNYSCHEW). Transverse sections of S.M. E 18789, × 1. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

Description

Alate shells with gently and equally convex valves and pointed cardinal extremities. Anterior border thin and often crushed. Umbones narrow and overarching interareas. Pedicle valve with narrow sulcus, containing prominent median plica. Brachial valve with high, narrow fold. Both valves with 3–4 or more lateral plicae, subangular posteriorly but broadening and becoming more rounded anteriorly, and also becoming lower and more obscure towards cardinal extremities. Plicae flanking pedicle sulcus equal height of brachial fold. Interareas rectangular, concave, with horizontal and prominent vertical growth lirae. Pedicle interarea apsacline 3–4 mm high; brachial interarea orthocline, 1 mm high. Hinge line completely denticulate. Surface of valves covered by relatively thick growth lamellae, numbering about 22 in 10 mm.

Pedicle valve interior has narrow median septum, extending into anterior half, thick adminiculae, and dental lamellae joined by short transverse delthyrial plate. Apical callosity in median and lateral chambers. Brachial valve interior has vertical crural lamellae and sessile, bifid cardinal process, striated longitudinally.

Discussion

This species was separated from *P. expansa* by STEPANOV who considered the larger size and more numerous lateral plicae of the Spitsbergen specimens were

sufficiently distinctive to indicate a different species, which he called *Spiriferina* (*Punctospirifer*?) *wimani*. However, no punctae of any kind or even a granular appearance of the shell can be seen in WIMAN's figures or in the specimens described here. *Spiriferina wimani* STEPANOV is a junior homonym. TSCHERNYSCHEW's figured specimens are smaller than the Spitsbergen ones but they show some variation in the number of lateral plicae and STEPANOV included one (TSCHERNYSCHEW, pl. 12, fig. 11) in *wimani*.

The presence of denticles along the hinge line is interesting. Vertical lirae are present on the interareas of several spiriferids and indicate hinge denticles. Such denticles occur in *Pterospirifer alatus* and are probably widespread in alate forms. DUNBAR (1955, p. 156) thought it probable that the present species was cogeneric with *Odontospirifer* DUNBAR. The latter genus has short dental lamellae and apparently no apical callosity (see DUNBAR 1955, p. 156, text fig. 22).

Occurrence

WIMAN records *P.* aff. *expansa* from the Spirifer Limestone and Brachiopod Chert of Bellsund, Stenbrohultdalen, Grønfjorden, Kapp Wijk, and Angelinberget. He also cites an example from the Cora Limestone of Bjørnøya. STEPANOV recorded it from Kapp Starostin, and FREBOLD from fossil level 12 (Middle Brachiopod Chert) of the Festningen section.

The specimens described above were collected from the Middle Brachiopod Chert, Bünsow Land, Gipshuken (S. M. E 17747–50, E 18789–90) and Kongsfjorden, west of Thiisbukta (S. M. E 18082); from scree *ex* Brachiopod Chert, Oscar II Land, Skivefjellet (X 666); from Spirifer Limestone, Kongsfjorden, Garwoodtoppen (D. 09.4, 09.24, 09 B 8).

Genus *Pterospirifer* DUNBAR, 1955, p. 128

Genotype: *Spirifer alatus* Schlotheim.

Pterospirifer cordieri (ROBERT)

Plate 20, fig. 13; plate 21, figs. 4–5

1845 *Spirifer cordieri* ROBERT, pl. 19, fig. K.
1850 *Spirifer alatus* var. DE KONINCK, p. 638, fig. 5.
1875c *Spirifer* cf. *alatus* TOULA, p. 238, pl. 5, figs. 5a–b.
1937 *Spirifer* cf. *alatus* FREBOLD, p. 49, pl. 2, fig. 2.
1937a *Cyrtospirifer? kharaulakhensis* STEPANOV, (not FREDERICKS 1931) p. 152, pl. 8, figs. 12–14.

Type data

Lectotype: the specimen figured by ROBERT, 1845, pl. 19, fig. K.
Type locality: Bellsund, Spitsbergen.

Discussion

This species is represented by few specimens. Apart from the two described by TOULA and the single specimen described by FREBOLD as *Spirifer* cf. *alatus*, I have seen an almost complete specimen (R.M.S. Br. 393) from Mariaholmen, Bellsund

and labelled "*Spirifer dieneri* TSCHERNYSCHEW", a fragment of an external mould (P.M.O. A 27839) collected by HOLTEDAHL from the "Productus flint" of Dronningfjella, Kongsfjorden, and a worn, silicified, pedicle valve (S. M. E 18345) from the Spirifer Limestone of Miseryfjellet, Bjørnøya.

TOULA's figured specimens were included by TSCHERNYSCHEW in the synonymy of *Spirifer dieneri*. They are worn but show traces of imbricated growth lamellae. The pedicle valve has eight lateral plicae which are subangular in cross section and decrease in height and width abaxially. The brachial valve is not certainly conspecific with it. It has 10 lateral plicae, more rounded in cross section and subequal in height and width.

There are at least 15 lateral plicae on the pedicle valve figured by FREBOLD. The specimen is an external mould and clearly shows imbricating growth lamellae and fine radial lirae. The specimen from Mariaholmen has a rectangular pedicle interarea, 6 mm high and with vertical lirae. The hinge is denticulate. The triangular delthyrium has an apical angle of 55°. There is no evidence of a delthyrial plate.

The silicified specimen may not be conspecific with the others. The exterior is worn but it is the only specimen showing the interior characters. It agrees with *Pterospirifer* in the form of the dental plates, the extent of callous in the posterior part of the valve, and the absence of a median septum.

Pterospirifer cordieri differs from *P. alatus* (SCHLOTHEIM) in having a narrower sulcus, more pronounced anterior tongue, shown by the growth lamellae in the sulcus, and broader, more widely separated plicae. The plicae bordering the sulcus are broader than the others whereas in *P. alatus* they are of the same width.

The *Pterospirifer alatus* recorded from the Zechstein of Lithuania by STEPANOV (1959, pl. 3, figs. 7 a–b) resembles *P. cordieri* in the form of the pedicle sulcus.

Spiriferinae gen. and sp. nov.
Plate 21, figs. 6–8

Description

Outline transversely trapezoidal, hinge line forming greatest width. Anterior commissure strongly uniplicate. Pedicle valve gently convex with sub-angular median sulcus extended anteriorly as rounded tongue. Umbo erect, damaged. Pedicle interarea high, apsacline, rectangular, slightly concave, marked with longitudinal lirae except for smooth perideltidium. Delthyrium equilateral-triangular. Brachial valve slightly more convex with sub-angular median fold. Umbo low and broad. Interarea low, orthocline. Both valves with low rounded costae, about five in 5 mm, more angular on umbo and dividing, particularly on flanks of fold and sulcus. Shell impunctate.

Interior of pedicle valve with dental plates (or *?adminiculae*) in umbonal region and transverse delthyrial plate with concave anterior border in posterior half of delthyrium. Other internal characters not seen.

Discussion

The single almost complete specimen (S. M. E 17979) described above has many characters of the Devonian genus *Cyrtospirifer* NALIVKIN (1930, p. 196).

It was collected from the Cora Limestone, Ymerdalen, Bjørnøya.

Subfamily Martiniinae WAAGEN, 1883

Genus *Martinia* M'COY, 1844, p. 128, 139.

For a diagnosis and discussion of this genus see DUNBAR (1955, p. 150).

Martinia sp. A.

Plate 21, figs. 9–10

Description

A single almost complete specimen. Outline rounded quadrate. Hinge line slightly less than greatest width. Pedicle valve evenly convex, venter flattened anteriorly, but no sulcus. Pedicle umbo narrow, inflated and sharply hooked over interarea. Small triangular apsacline interarea lying at obtuse angle to postero-lateral slopes. Brachial valve with broad median fold. Umbo small and pointed; interarea very low, orthocline. Anterior commissure uniplicate. Surface of shell smooth, with fine growth lirae. Brachial valve exfoliated and muscle field seen to be subcircular in outline and marked by fine longitudinal ridges. Shell thin and translucent so that the infilling matrix can be seen through it. Valves without apical callosity and aseptate.

Discussion

This shell does not resemble any described species of *Martinia* that I have found in the literature. It is perhaps nearest in form to *M. assinuata* IVANOVA from the upper half of the Viséan of the Moscow Basin. *M. assinuata* however has a transversely oval outline.

Occurrence

Base of the Lower Gypsiferous Series, Ebbadalen, Billefjorden, (S. M. E 17913). Also one pedicle valve which may belong to this species, from the Wordiekammen Limestone, Burn Murdochbreen, Bünsow Land, (P. M. O. A 26411).

Martinia? sp. B.

Plate 21, figs. 11–12

A single internal mould with some unsculptured shell (P. M. O. H 4968), labelled *Martiniopsis uralica* TSCHERNYSCHEW, shows no trace of internal septa. It was collected from the east side of Trygghamna (i. e. Brachiopod Chert).

Other smooth spiriferids have been collected from the Brachiopod Chert, but they are not sufficiently complete to be identified.

Superfamily Athyracea WILLIAMS, 1956
Family Athyridae WAAGEN, 1883 (not PHILLIPS, 1841)
Subfamily Athyrinae WAAGEN, 1883

Genus *Cleiothyridina* BUCKMAN, 1906

1850 *Cleiothyris* KING (not PHILLIPS), p. 138.
1893 *Cliothyris* HALL and CLARKE, p. 90.
1906 *Cleiothyridina* BUCKMAN, p. 324.

Diagnosis

Sub-equally biconvex *Athyracea* with rounded shell outline and small pedicle umbo perforated at apex by small circular foramen. Sculpture of concentric lamellae bordered by flattened spines. Brachial valve interior with hinge plate perforated at umbo, bordered by deep dental sockets and bearing long slender crurae. Jugum present and jugal lamellae follow curve of spiralia, ending between first and second coil.

Genotype: *Athyris roysii* DAVIDSON.

Discussion

PHILLIPS (1841, p. 55) first used the generic name *Cleiothyrus* to replace *Atrypa*, which he thought "objectionable". In 1850 KING recognized that the name was a junior synonym and "used it up" on a new genus, incorrectly spelling it *Cleiothyris*. The genotype of KING's genus was *Atrypa pectinifera* J. DE C. SOWERBY. BUCKMAN revised this genus, named it *Cleiothyridina* and gave it a new genotype.

Cleiothyridina royssiana (KEYSERLING)
Plate 21, figs. 13–16; plate 22, figs. 1–2

1845 *Terebratula roissyi* VERNEUIL, (not L'ÉVEILLÉ), p. 55, plate 9, figs. 2a–b.
1846 *Terebratula royssiana* KEYSERLING, p. 237.
1854 *Terebratula royssiana* KEYSERLING, p. 109, pl. 4, figs. 31–33.
1911 *Athyris royssiana* NETSCHAJEW, p. 153, pl. 13, figs. 1–7.
1914 *Athyris royssiana* WIMAN, p. 30, pl. 1, figs. 21–55, pl. 2, figs. 1–13.
1931 *Athyris royssiana* FREBOLD, p. 29.
1937a *Athyris* (*Cleiothyridina*) *royssiana* STEPANOV, p. 156, pl. 9, figs. 8–10.
1950 *Athyris royssiana* FREBOLD, p. 69, pl. 6, figs. 6–6a, 7–7a.
1952 *Athyris royssiana* WANG, p. 347.
1958 *Athyris royssiana* FORBES, p. 475.

Type data

Lectotype (here selected): the shell figured by VERNEUIL 1845, pl. 9, figs. 2a–b, under the name *Terebratula roissyi*.

Type locality: limestones in the vicinity of Kirilov, U.S.S.R., 60° N., 38° E.

Description

Shell outline transversely oval. Relative width varies but always greater than length. Pedicle valve thick, slightly convex, with broad umbo, protruding slightly

from posterior margin, and with small terminal pedicle opening. No deltidial plates preserved and probably not present, delthyrium being filled by broad convex brachial umbo. Shallow pedicle sulcus anteriorly, becoming deeper near anterior border where it is about one fifth maximum width of valve.

Brachial valve thin, convex, with broad median fold, and flattened flanks sloping to lateral margin.

Sculpture of fine concentric lamellae, numbering 20–50 in 10 mm, each with a fringe of small flattened spines.

Pedicle valve interior has muscle field subcircular to longitudinally oval in outline and deeply impressed. Divaricator impressions large, extending almost to anterior margin, adductors small, lanceolate in outline, and lying posteriorly. Teeth large and project from thickened umbonal slopes. Flanks thickened and pitted; lateral and anterior borders sometimes thickened and geniculated.

Brachial valve interior with hinge plate, rounded triangular in outline, perforated (a passage running dorsal to it from tip of umbo into shell cavity), and bordered laterally by deep dental sockets. Thin, low, median septum posteriorly. Spiralia preserved in one specimen shows 18 turns and is pectinated; jugum damaged, but appears to have central lamella which forks dorsally.

Discussion

KEYSERLING's figure shows a more prominent fold and sulcus than is present in the Spitsbergen specimens, although this is variable in the latter. No internals are shown. NETSCHAJEW figures several Russian specimens showing the variation of the shell outline and the internal characters of the pedicle valve which are closely comparable with those of the Spitsbergen specimens. Those from north-east Greenland figured by FREBOLD (1950) are transversely extended forms.

Cliothyris royssiana TSCHERNYSCHEW (1902, p. 511, pl. 43, figs. 11–12, text fig. 39) does not belong to KEYSERLING's species. The pedicle umbo is narrow and protrudes posteriorly from the general outline of the shell. Also the muscle impressions in the pedicle valve are restricted to its posterior part.

Occurrence

This species is widespread in the Permian of European Russia. In Svalbard it is abundant in the Spirifer Limestone. It is also known from north-east Greenland. Spirifer Limestone, Bünsow Land, Gerardfjella (S. M. E 18371–3); Bjonahamna (S. M. E 18461–85); Gipshuken (S. M. E 17572–3); Tyrrellfjellet (S. M. E 17605); Robertfjellet (S. M. E 17096); Sassendalen (S. M. E 18323–6, E 18433–44); Oscar II Land, Heimberget (X 674(4)). Lower Brachiopod Chert, Oslobreen, station G 859 (S. M. E 18158–62); Komarovfjellet (S. M. E 18386); Tempelfjorden, west of Kapp Schoultz (S. M. E 18218); Templet (S. M. E 18225); Gipshuken (S. M. E 18747). Middle Brachiopod Chert, Gipshuken (? E 17677, ? E 18799).

Cleiothyridina kotlukovi STEPANOV
Plate 22, figs. 3–4

1914 *Athyris* sp. WIMAN, p. 31, pl. 2, fig. 14.
1936 *Athyris* (*Cleiothyridina*) *kotlukovi* STEPANOV, p. 124, 128, pl. 5, figs. 5–6.
1937a *Athyris* (*Cleiothyridina*) *kotlukovi* STEPANOV, p. 157, 182, pl. 9, figs. 6–7.

Type data

Lectotype (here selected): the specimen figured by STEPANOV 1936, pl. 5, fig. 6 and 1937, pl. 9, fig. 7.

Type locality: Brachiopod Chert, 200 m from the end of Kapp Starostin, Isfjorden, Spitsbergen.

Description

Large, transversely oval in outline. Valves approximately equal in size and convexity, resembling a lamellibranch. Brachial valve probably the more convex but specimens all somewhat crushed. Very slight pedicle sulcus and dorsal fold give anterior commissure a slight flexure. Sculpture of concentric comb-like lamellae, fringed with long flattened spines, spines arising from lamellae in middle of valve reach anterior margin.

Interior of pedicle valve thickened and pitted with deep pear-shaped muscle field in posterior half. Adductors narrow, confined to flanks of low median septum, which does not extend anterior to muscle field. Divaricators large and longitudinally striated. Teeth large. Brachial valve relatively thin, and sculpture visible on internal mould.

Discussion

WIMAN figured the interior of a broken pedicle valve. STEPANOV's figures are poor, an internal mould and a weathered pedicle valve, but the specimens described here resemble them in size and shape. STEPANOV (1937 a, p. 182) described the species as follows:

> The shell is transverse-oval in outline. The length of the hinge line is less than the maximum width of the shell. The ventral and dorsal valves are almost equally convex. The sinus and septum are very slightly developed and are noticeable only in the second half of the length. The sculpture and the character of the scars of attachment of the muscles is similar to those in *Ath. royssiana* KEYS. The form described differs from the latter not only by its huge size, but also by the different outlines of its shell.

Occurrence

Brachiopod Chert, Spitsbergen. WIMAN recorded it from Angelinberget, Nordaustlandet, and Akseløya, Bellsund. The specimens described here are from the Lower Brachiopod Chert, Sassenfjorden, Belvedere (S. M. E 18065); Middle Brachiopod Chert, Gipshuken (S. M. E 18269, E 18752–3, E 18796–8); Brachiopod Chert, Tempelfjorden, Rejmyrefjellet (P.M.O. A 26467); Chydeniusbreen, Mertonberget, scree (S. M. E 18060); Cepheusfjellet, scree (specimen lost); Oscar II Land, Skivefjellet (X 648); Heimberget (X 669).

Cleiothyridina cf. *sibirica* EINOR
Plate 22, figs. 8–10

Cf. 1939 *Cleiothyridina capillata* var. *sibirica* EINOR, p. 94, 136, pl. 15, figs. 7–10.

Description

Outline transversely suboval. Pedicle valve slightly concave with narrow median groove broadening into shallow sulcus posteriorly. Apical angle about 130°. Brachial valve convex, roof-shaped in cross section. Anterior commissure uniplicate. Sculpture of concentric lamellae. Greatest thickness central or near anterior border. Valves worn. Internal characters not seen.

Discussion

These Spitsbergen shells differ from EINOR's description in having a larger apical angle and a brachial fold extending to the umbo. However, the latter appears to be the case in EINOR's fig. 7 b. The species is less convex and more transverse than *C. capillata* (WAAGEN).

Occurrence

Upper Cyathophyllum Limestone, Kapp Schoultz (P. M. O. A 26342–50). *C. sibirica* EINOR is from the Lower Permian of the Tareia river, west Taimyr, U. S. S. R.

Cleiothyridina aff. *maynci* DUNBAR, 1955
Plate 22, figs. 11–13

1958 *Squamularia guadalupensis* FORBES, (not SCHUMARD), p. 474.

Description

Outline rounded pentagonal. Greatest width across centre of valves. Valves equally convex. Pedicle umbo narrow, slightly protruding and strongly incurved over umbo. Anterior part of pedicle valve flattened and anterior commissure uniplicate but no development of sulcus or fold. Sculpture of concentric lamellae but detail obscure.

Discussion

In external characters this form is closely comparable with *C. maynci* DUNBAR 1955, p. 125, pl. 22, figs. 1–8, from the Upper Permian of central east Greenland.

Occurrence

Upper Wordiekammen Limestone, Brisingefjellet (S. M. E 17342), locality unknown (P. M. O. A 9772), scree, Gipsvika (S. M. E 18361).

Cleiothyridina cf. *stuckenbergi* (NETSCHAJEW)
Plate 22, figs. 5–7

Cf. 1911 *Athyris stuckenbergi* NETSCHAJEW, p. 154, pl. 14, figs. 5–8.

Description

Outline oval, transversely extended or elongate. Greatest thickness central. Pedicle valve moderately convex with small umbo and shallow, poorly defined sulcus anteriorly. Brachial valve more convex with obscure fold. Anterior commissure uniplicate. Sculpture of concentric lamellae.

Discussion

There is a considerable variation in the specimens which are all from one block. It is difficult to define limits of variation of such forms as *C. subexpansa* WAAGEN and *C. capillata* WAAGEN, some figured specimens of which resemble those described here. However, these species normally have a more prominent pedicle umbo and the valves are more nearly equal in convexity.

Occurrence

Brachiopod Chert, Ahlstrandodden, Bellsund (P. M. O. A 28313–8). *C. stuckenbergi* occurs in the Kazanian of the north Ural.

Genus *composita* BROWN, 1849

1849 *Composita* BROWN, p. 131.
1893 *Seminula* HALL and CLARKE (not M'COY 1844), p. 93.
1906 *Composita* BUCKMAN, p. 324.

Diagnosis

Small *Rostrospiracea* with pentagonal outline, smooth shell surface and epithyrid type of umbo. Sulcus and fold typically developed.

Genotype: *Spirifer ambiguus* J. SOWERBY.

Discussion

The diagnosis of *Composita* given by BROWN is as follows:

Shell somewhat pentangular, hinge line very short, beak of the larger valve produced, with a small circular perforation; inside furnished with spiral appendages. This genus is founded upon the *Spirifer ambiguus* of SOWERBY. . .

HALL and CLARKE confused *Composita* BROWN with *Seminula* M'COY 1844. The genolectotype of *Seminula* was designated by HALL and CLARKE (1893, p. 93) as *Terebratula pentaëdra* PHILLIPS. These authors followed DAVIDSON in assuming this species to be synonymous with *S. ambiguus* J. SOWERBY. BUCKMAN argued that *T. pentaëdra* was generically distinct and allied to *Camerophoria*. This was contested by VAUGHAN. However, the specimen of *T. pentaëdra* figured by PHILLIPS (1836, pl. 12, fig. 3) appears distinct from *T. ambigua* (SOW.) figured by

him (ibid., pl. 11, fig. 21). *T. pentaëdra* has a narrow, hooked umbo of hypothyrid type and *T. ambigua* a broad umbo with a large pedicle foramen. The species attributed to *Seminula* by HALL and CLARKE have the latter form and clearly belong to *Composita* BROWN.

Composita ambigua (J. SOWERBY)
Plate 22, figs. 14–17, text fig. 23

1823 *Spirifer ambiguus* SOWERBY, p. 105, t. 376.
1863 *Athyris ambigua* DAVIDSON, p. 77, part, pl. 15, figs. 15–23, pl. 17, figs. 11–14.
1900 *Athyris ambigua* ANDERSSON, p. 255.
1914 *Athyris ambigua* WIMAN, p. 29.
1952 *Athyris ambigua* SARYCHEVA and SOKOLSKAYA, p. 235, pl. 69, No. 399.

Type data

SOWERBY figured only one specimen. This was from the Carboniferous Limestone near Bakewell, Derbyshire.

Description

Outline rounded pentagonal. Length and width normally approximately equal but some shells more transverse, others elongated. Valves moderately convex. Height greatest through centre and equals half to two thirds width. Pedicle valve has prominent umbo with large pedicle opening. Median sulcus well-defined, narrow and groove-like, remaining constant in width or broadening and widening slightly towards anterior border. Lateral sulci more or less developed anteriorly. Brachial valve has lateral folds and median fold divided by median groove, deep in some specimens but scarcely visible in others. Anterior commissure parasulcate or episulcate. Surface of valves smooth, marked by concentric growth lines.

Internal moulds show narrow adductor muscle impressions posteriorly placed and divided on brachial valve into elongate oval anterior pair and long, narrow posterior pair. Divaricator impressions lightly impressed occupying an extensive area and radially striated.

In a sectioned specimen (see text fig. 23) spiralium has 11 turns; jugum damaged but traces of jugal lamellae visible.

Discussion

The Svalbard specimens compare closely with specimens of *C. ambigua* in the Sedgwick Museum. The latter show considerable variation in size and in the form of the sulcus and fold. Most of the Svalbard specimens are small but some reach 20 mm in length. *Seminula trinuclea* HALL from the St. Louis Limestone of Indiana (HALL 1893, pl. 47, figs. 5–6, 10–14) is similar and may be conspecific. LICHAREW and EINOR (1939, p. 221, pl. 28, figs. 9–11) described *C. ambigua* var. *abrassimovoensis* from Lower Permian deposits on the west coast of the North Island of Novaya Zemlya. In external characters the figured specimens resemble those described here.

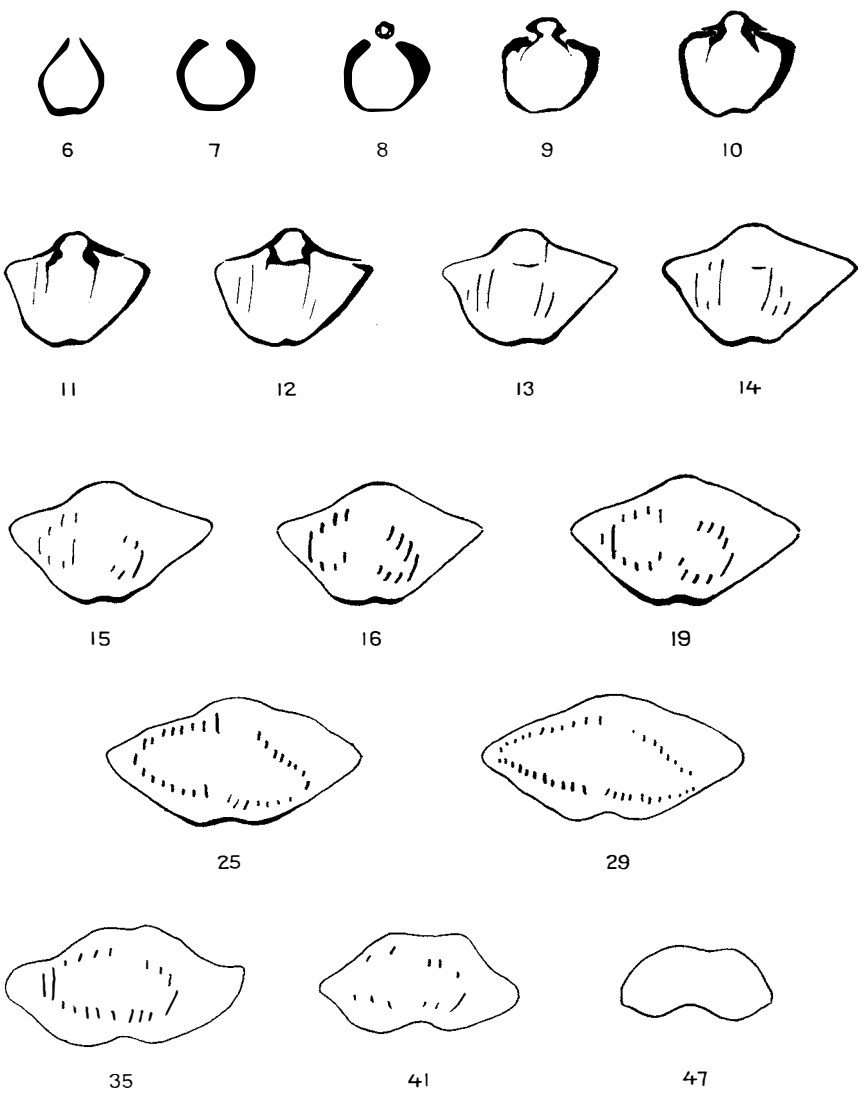

Fig. 23. *Composita ambigua* (SOWERBY). Transverse sections of X 635, × 2. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

Occurrence

In the Moscow basin *C. ambigua* ranges from Upper Viséan to Lower Stephanian but is most frequent at the top of the Viséan.

In Svalbard it occurs as follows: – Spitsbergen, Billefjorden, Lower Gypsiferous Series, Ebbadalen (S. M. E 17907–10); De Geerfjellet (S. M. E 18112–3); Passage Beds, Sfinksen (? E 18133); Oscar II Land, Tårnkanten Sandstone, Tårnkanten (X 607(22)); Jutulslottet (X 616(6)); Robertsonfjellet (X 635(62), X 636 (8), S. M. E 18842–9). Bjørnøya, Ambigua Limestone, north of Kapp Kåre (S. M. E 17981); Kobbebukta (S. M. E 18352–6).

Composita sp. A.
Plate 22, figs. 18–20

Description

Outline rounded-quadrilateral. Valves strongly convex, convexity of brachial valve equal to or greater than that of pedicle valve. Height slightly less than width. Postero-lateral margins produced into small flattened ears, rounded in outline. Pedicle valve with small, inflated umbo, venter more convex than flanks, and broad sulcus anteriorly. Brachial valve with obscurely defined median fold, and, in cross section, approximates to a parabola. Anterior commissure uniplicate. Surface exfoliated, marked only by growth lines.

One specimen serially ground but spiralia not preserved. An internal mould shows narrow adductor muscle impressions immediately anterior to pedicle umbo and narrow radial ridges, 4–5 on each side of mid-line, representing grooves on the internal surface of pedicle valve.

Discussion

These shells (R.M.S. Br. 10271–9) differ from most *Composita* species in their quadrate outline and weakly developed sulcus. In these characters they resemble *Composita damesi* (FLIEGEL 1901, p. 104, pl. 7, figs. 8–10) from the Permian of Padang, Sumatra. *C. damesi*, however, is a larger species with a more elongated pedicle umbo. The internal characters cannot be compared and there is no reason to suppose that the two forms are related. The value of the present specimens is impaired since their stratigraphical horizon and locality are unknown.

Composita sp. B
Plate 22, figs. 21–24

Cf. 1915 *Spirigera xetra* DIENER, p. 91, pl. 9, figs. 13–17.
Cf. 1931 *Athyris xetra* REED, p. 28, pl. 5, figs. 5–6.

Description

Outline rounded pentagonal to sub-triangular. Greatest height central in most specimens, but in one, lying near anterior border which is thus truncated. Valves thick. Pedicle valve convex with narrow, produced umbo, slightly concave postero-lateral margins, and broad, shallow sulcus anteriorly. Brachial valve more convex, roof-shaped in cross section. Anterior commissure uniplicate. Shell partly exfoliated but no trace of sculpture other than growth lines.

Discussion

This species is strikingly similar to *Composita xetra* (DIENER), from the Zewan Beds of Kahmir and the Productus Limestone of the Salt Range. Both show a considerable variation in shape but *C. xetra* has a more convex pedicle valve. The specimen figured by REED (1931 a, pl. 5, fig. 5 b), shows narrow radial ridges on the exfoliated pedicle valve. These are clearly visible in some of the Spitsbergen specimens. Unfortunately no details of the interior are known of the Spitsbergen or of the Indian form.

Occurrence

Upper Cyathophyllum Limestone ?, Chydeniusbreen, Mertonberget (S. M. E 17994–9).

Superfamily Punctospiracea COOPER, 1944
Family Spiriferinidae DAVIDSON, 1884
Subfamily Syringothyrinae SCHUCHERT and LEVENE, 1929

Genus *Syringothyris* WINCHELL, 1863, p. 6.

Diagnosis

Pedicle valve conical with high interarea, divided into inner and outer zones. Sulcus and fold well developed, usually smooth. Lateral areas with simple costae. Convex deltidium rarely preserved. Transverse delthyrial plate carrying a split tube or syrinx beneath it. Dental plates long and slender, attached to floor of pedicle valve for about a third of its length.

Genotype: *Syringothyris typa* WINCHELL.

Syringothyris spitzbergensis WIMAN

1914 *Syringothyris spitzbergensis* WIMAN, p. 51, pl. 8, figs. 5–7.

Type data

Lectotype (here selected): R. M. S. Br. 909, the specimen figured by WIMAN (see above). This is the only complete specimen that has been collected. Its locality and stratigraphical horizon are unknown.

Description

Outline trapezoidal. Greatest width along hinge line, approximately equal to height and greater than length. Pedicle valve has large, flat triangular catacline interarea, broad rounded median sulcus extending as long, rounded anterior tongue, and convex flanks. Brachial valve convex with low orthocline interarea and flat-topped, steep-sided median fold, broadening anteriorly. Anterior commissure strongly uniplicate.

Pedicle interarea with apical angle of 90° and slightly concave near umbo. Large triangular delthyrium with delthyrial angle of 30°. Surface of interarea divided into inner zone with horizontal and vertical lirae and outer zone with horizontal lirae only.

Sulcus and fold smooth. Lateral areas of valves with 10 or more low, rounded costae, 2–3 mm wide in middle of their length and above 4 mm wide at anterior commissure.

Interior of pedicle valve has long, thin dental plates, united by transverse delthyrial plate bearing syrinx on its interior surface. Shell punctate, about 50 punctae in 1 sq. mm in sulcus, less numerous on interarea.

Discussion

WIMAN said *S. spitzbergensis* differed from *S. cuspidatus* (MARTIN) in its higher brachial valve and broader pedicle interarea. The latter species shows considerable variation in the form of the interarea and size of the plication of the anterior commissure. However, most specimens have a procline interarea and when the shell is viewed normal to this the flanks of the brachial valve are not visible. *S. spitzbergensis*, viewed in this way, shows the full width of the brachial valve which thus appears higher. Also the pedicle umbo and sides of the interarea appear more rounded than those of *S. cuspidata*. Most other species of similar size are more transverse. *S. typa* WINCHELL is similar but appears from HALL's figures (HALL and CLARKE, 1894, pl. 27, figs. 1–2) to have a more convex pedicle valve.

Genus *Pseudosyrinx* WELLER, 1914

1914 *Pseudosyrinx* WELLER, p. 404.
?1916 *Cyrtia* FREDERICKS, (not DALMAN), p. 39.
?1919 *Cyrtella* FREDERICKS, p. 312.

Diagnosis

Externally similar to *Syringothyris* WINCHELL. Pedicle valve flanks usually rounding into cardinal area. Interior of pedicle valve with transverse delthyrial plate but syrinx absent. Delthyrial supporting plates long, sometimes reaching anterior to middle of valve. Shell punctate.

Genotype: *Pseudosyrinx sampsoni* WELLER.

Discussion

WELLER (1914, p. 404) remarked:

> The genus *Pseudosyrinx* has been established to include a group of spiriferoid shells with high cardinal area, punctate shell structure, and distinct delthyrial plate which differs from that in *Syringothyris* in the entire absence of a syrinx upon its inner surface.

FREDERICKS (1916, p. 39–54) identified spiriferoids with a transverse plate in the delthyrium (the *Spirifer ostiolati* of HALL and CLARKE) with the genus *Cyrtia* DALMAN, later (FREDERICKS 1919, p. 312) revising this to *Cyrtella*. From this genus were derived forms with a ridge-like or tube-like structure lying along the inner side of this delthyrial plate. FREDERICKS recognized three developments which he assigned to different genera. *Pseudosyringothyris*, represented by one species *P. karpinskii*, had a ridge, bilobed in cross section (see further discussion under this genus).

Prosyringothyris was based on sections of *Syringothyris* aff. *carteri* figured by NORTH (1913, pl. 12, figs. 1–7) which shows the split tube or syrinx characteristic of *Syringothyris*. This species was later described by NORTH (1920, p. 182) as *Syringothyris principalis*. FREDERICKS, however, did not consider this open tube characteristic of *Syringothyris* but of a new genus *Prosyringothyris* and he renamed NORTH's *S.* aff. *carteri, Prosyringothyris northi,* making this the genotype.

FREDERICKS (1916, pl. A facing p. 48, and fig. 12, p. 48) figured a Russian specimen which he identified with *S. carteri* HALL and which possessed a syrinx in the form of a closed tube. This represented the true *Syringothyris*. *S. carteri* HALL, however, has a split tube, and so do all other species of *Syringothyris*, of which I have seen sections. FREDERICKS' specimen is an exception.

Thus *Prosyringothyris* FREDERICKS is a junior synonym of *Syringothyris* WINCHELL.

Cyrtella FREDERICKS, if punctate, is probably synonymous with *Pseudosyrinx* WELLER. If impunctate it may be synonymous with *Cyrtospirifer* NALIVKIN. LICHAREW (1934 c, p. 123) put *Cyrtella* in the synonymy of *Pseudosyrinx*.

Although WELLER explicitly stated that *Pseudosyrinx* is punctate, COOPER (1954, p. 331–2) said it was not punctate. Thin sections of the shell of the following species, which I tentatively assign to *Pseudosyrinx*, show minute punctae in the secondary layer of the shell, when this is suitably preserved.

Pseudosyrinx wimani sp. nov.
Plate 23, figs. 1–3

1914 *Spirifer tastubensis* WIMAN, (not TSCHERNYSCHEW), p. 45, pl. 7, figs. 5–8.
1958 *Spirifer tastubensis?* FORBES, p. 475.

Type data

Holotype: S. M. E 17500.
Paratypes: R.M.S. Br. 1086, S. M. E 17947, E 18666.
Type locality: Spirifer Limestone, Usherfjellet, Bünsow Land.

Description

Syringothyriform. Greatest width at hinge line, about twice length and 1½ times height. Pedicle valve pyramidal with high catacline interarea, of variable concavity, marked by horizontal and vertical lirae. Umbo narrow. Apical angle about 130°, delthyrial angle about 60°. Sides of delthyrium grooved and convex deltidium was probably present. Sulcus, rounded in cross section, rapidly broadening anteriorly, and triangular in outline. Anterior commissure strongly uniplicate.

Brachial valve slightly and regularly convex. Broad, low median fold which does not project anteriorly. Low orthocline interarea.

Both valves sculptured with simple rounded plicae, broader than the interplical sulci, numbering six on fold and sulcus and 10–11 on flanks.

Interior of pedicle valve with thick dental lamellae, joined to posterior half of valve floor by long, thin adminiculae, diverging and bordering rounded-triangular muscle field. Proximal quarter of delthyrium contains transverse plate strongly united by secondary shell material to dental lamellae. Inner surface of transverse delthyrial plate bears no projection or structure resembling a syrinx.

Interior of brachial valve and details of spiralia unknown.

Discussion

WIMAN assigned this species to *S. tastubensis* TSCHERNYSCHEW with considerable doubt, especially concerning the outline of the shell and the width of the delthyrial opening. TSCHERNYSCHEW's species, as figured (TSCHERNYSCHEW, 1902, pl. 9, figs. 1–3) is more extended transversely, has a greater apical angle (150°) and a smaller delthyrial angle (30°). TSCHERNYSCHEW does not describe the internal characters.

Pseudosyrinx wimani sp. nov. resembles *Pseudosyrinx kolymensis* (TOLMATCHOFF), a form from eastern Siberia described by LICHAREW (1934 c, p. 122, pl. 2, figs. 1–2, 6, pl. 3, figs. 1, 5–7), but the latter has smaller apical and delthyrial angles and high brachial fold which projects anteriorly. LICHAREW thought this species conspecific with *Pseudosyrinx kulikianus* (FREDERICKS). *P. kolymensis taimyrica* EINOR differs from *P. kolymensis* only in the greater number (about 20) of costae on the flanks of the valves.

Occurrence

Spirifer Limestone, Spitsbergen, Usherfjellet (S.M. E 17500); Templet (S. M. E 18666); Kapp Wijk (S. M. E 18301). Bjørnøya, Alfredfjellet (S. M. E 17947); Nord Kapp (R.M.S. Br. 1086 – figured by WIMAN).

Pseudosyrinx arcticus? (WHITFIELD)

Plate 23, figs. 4–5

?1908 *Syringothyris arctica* WHITFIELD, p. 53, pl. 3, figs. 5–8.
1937a *Pseudosyrinx? arcticus* STEPANOV, p. 153, 181, pl. 9, figs. 1, 4.
?1939 *Pseudosyrinx?* sp. nov. LICHAREW and EINOR, p. 221, pl. 28, figs. 6a–c, 7.
1952 *Neospirifer marcoui* WANG, (not WAAGEN), p. 347.

Description

Syringothyriform, with greatest width at hinge line. Pedicle valve pyramidal, interarea catacline, slightly concave. Apical angle 130°; delthyrial angle 50°. Deep, sub-angular median sulcus, broadening anteriorly and triangular in outline. Brachial valve crushed; it has median fold and narrow, orthocline interarea. Brachial umbo flattened and sharply incurved over the base of delthyrium. Sulcus and fold bear traces of plicae. About 12 rounded plicae on flanks, broader than interplical sulci.

Interior of pedicle valve with dental lamellae, adminiculae diverging anteriorly and lying lateral to sulcus, and transverse delthyrial plate with concave anterior border. Syrinx absent. Shell minutely punctate in the secondary layer.

Discussion

Three specimens are similar in form to WHITFIELD's species but it is not known whether a syrinx is present in the latter and also there is no sign of adminiculae in WHITFIELD's figures. STEPANOV identified *Spirifer tastubensis* WIMAN, not TSCHERNYSCHEW, with this species. However, there are great differences in the form of the interarea and sulcus.

Occurrence

STEPANOV recorded this species from the Spirifer Limestone of Tempelfjorden and Kapp Starostin. The specimens described here are from the Spirifer Limestone, Tyrellfjellet (S. M. E 17112); Bjonahamna (S. M. E 18565); and from the Middle Brachiopod Chert, Gipshuken (specimen lost).

Pseudosyrinx sp.
Plate 23, figs. 6–9

1937a *Spirifer* sp. indet. STEPANOV, pl. 9, figs. 2–3.

Description

Transversely extended, hinge line forming greatest width. Pedicle valve convex with prominent median sulcus, broadening anteriorly. Umbo incurved over high, gently concave apsacline interarea, with apical angle of 140° and delthyrial angle of 60°. Brachial valve short, convex posteriorly, flattening laterally and anteriorly. Umbo broad, incurved over low concave orthocline interarea with wide notothyrium. Median fold low, triangular in outline.

Sulcus and fold with low, obscure plicae; lateral plicae simple, about 15 on each side of mid-line, broadening anteriorly. Shell finely punctate.

Pedicle valve interior with dental lamellae and transverse plate fused with apical callosity. Adminiculae diverging around broad, rounded muscle field.

Discussion

This species is represented mainly by isolated brachial valves. There are two pedicle valves, one with the umbonal part of the brachial valve, but it is not certain that all the specimens belong to one species. The specimens show some similarity with *Cyrtospirifer kharaulakhensis* FREDERICKS but are not conspecific with specimens so named by STEPANOV 1937 a (see *Pterospirifer cordieri* (ROBERT)). They also resemble *Pseudosyrinx kulikiana* (FREDERICKS) which LICHAREW (1934, p. 123) though could not be distinguished from *P. kolymensis* (TOLMATCHEFF). *P. kulikiana,* although showing considerable variation, has a relatively higher interarea, a narrower delthyrium and higher brachial fold than the form described above.

Occurrence

Spirifer Limestone, Tempelfjorden, Bjonahamna (S. M. E 18579–82); Rejmyrefjellet (P. M. O. A 26247–8); Gerardfjella (S. M. E. 18363); Usherfjellet (S. M. E 18671–3); west of Burn Murdochbreen (S. M. E 18208); Gipshuken (S. M. E 17545).

Genus *Pseudosyringothyris* FREDERICKS 1916, p. 51.

Diagnosis

Punctate spiriferoids resembling *Syringothyris* in external form. Dental lamellae well-developed but adminiculae short. Transverse delthyrial plate bearing on its inner surface a median, solid, roller-like callosity.

Genotype: *Pseudosyringothyris karpinskii* FREDERICKS.

Discussion

FREDERICKS created this genus for one species which has a remarkable callosity or pseudosyrinx in the ventral side of the delthyrial plate. He thought it to be an intermediate stage between *Cyrtia* (*Cyrtella, Pseudosyrinx*) and *Syringothyris* (see discussion of *Pseudosyrinx*). No other records of this structure have been published and most authors (e. g. SCHUCHERT and LEVENE 1929, PAECKELMANN 1932) have treated *Pseudosyringothyris* as a junior synonym of *Pseudosyrinx* WELLER. However, besides the pseudosyrinx, *Pseudosyringothyris* possesses dental lamellae attached to the floor of the valve by adminiculae only for the proximal third of the delthyrium.

On sectioning some of the *Syringothyris*-like spirifers from Spitsbergen, I found a callosity on the inner surface of the transverse delthyrial plate, which although smaller and not so distinctly bilobed as that of *P. karpinskii,* is directly comparable to it. Also the adminiculae are shorter than those of *Pseudosyrinx*.

Pseudosyringothyris borealis sp. nov.
Plate 22, fig. 28, plate 24, figs. 1–4

1958 *Cyrtina septosa* FORBES, (not PHILLIPS), p. 475.

Type data.

Holotype: S. M. E 18575.

Paratypes: R. M. S. Br. 101926, S. M. E 18578.

Type locality: Spirifer Limestone, Bjonahamna, Tempelfjorden, Spitsbergen.

Description

Syringothyriform with greatest width at hinge line. Pedicle valve pyramidal with very high, broad, flat catacline interarea and large triangular delthyrium. Apical angle 140°; delthyrial angle 40°. Pedicle sulcus shallow, rounded in cross section, broadening anteriorly and extending as tongue. Brachial valve transverse, strongly curved longitudinally with broad, incurved umbo and low, median fold, broadening anteriorly. Brachial interarea low, concave apsacline. Sulcus and fold smooth; flanks sculptured with low, rounded plicae, about 10 on each side. Shell finely punctate.

Interior of pedicle valve with small apical and extensive lateral callosities. Posterior half of delthyrium contains transverse plate bearing on its inner surface a rounded median ridge of solid shell material, quite distinct from apical callosity. Hinge teeth relatively small; dental lamellae prominent, joined to floor of valve by adminiculae in posterior third of their length. Pedicle and brachial muscle fields elongate oval in outline, longitudinally striated, latter divided by low median septum.

Discussion

This species differs from *Pseudosyringothyris* sp. (see below) in its larger apical and delthyrial angles. The transverse delthyrial plate is longer than that of *P. karpinskii* which also has a larger pseudosyrinx.

Occurrence

Spirifer Limestone, Tempelfjorden, Bjonahamna (S. M. E 18575, E 18578); Gerardfjella (S. M. E 18358); Gipshuken (S. M. E 17581); (R. M. S. Br. 101926). Scree, Brucebreen (specimen lost); unlabelled (R. M. S. Br. 101984, Br. 834).

Pseudosyringothyris sp.
Plate 23, fig. 10

Three pedicle valves differ from *Pseudosyringothyris borealis* sp. nov. in smaller size and smaller apical (120°) and delthyrial (35°) angles. The shell surface is poorly preserved but pedicle flanks have at least eight low, rounded, simple costae. Thin sections of the shell show no signs of punctae, probably due to recrystallization. The form of the transverse delthyrial plate, pseudosyrinx, and dental lamellae, and the distribution of callous is the same as that of *Pseudosyringothyris borealis* sp. nov.

Occurrence

Spirifer Limestone, Bjonahamna (S. M. E 18576–7); ?Spirifer Limestone, west ridge of Skedvifjella (S. M. E 18875).

Subfamily Spiriferininae SCHUCHERT and LEVENE, 1929

Genus *Spiriferina* D'ORBIGNY, 1847

1847 *Spiriferina* D'ORBIGNY, p. 268.
1919 *Spiriferellina* FREDERICKS, p. 299.

Diagnosis

Coarsely punctate spiriferoids without a transverse delthyrial plate. Pedicle valve with median septum, well-developed dental lamellae and short adminiculae. Jugum simple, not V-shaped. Surface of the valves with small prostrate spines and growth lamellae.

Genotype: *Terebratulites rostrata* SCHLOTHEIM.

Discussion

Spiriferina D'ORBIGNY is based on a Liassic species. D'ORBIGNY (1850, p. 168) put the Permian *S. cristata* in the genus *Cyrtia* DALMAN. However, no clear reasons have been put forward for separating the Palaeozoic and Mesozoic species into different genera. FREDERICKS argued that the Palaeozoic forms, which he called *Spiriferellina,* possessed a median euseptum in the pedicle valve, formed from a fold in the mantle over the pedicle valve floor. *Spiriferina s. s.* had a pseudoseptum which grew ventrally from the delthyrial plate. However, OEHLERT (1901, p. 244, fig. 3) figured a section of *S. rostrata,* the genotype of *Spiriferina,* which shows the ventral septum as a euseptum, in the sense of FREDERICKS. MILORADOVICH (1937, p. 533, p. 511, fig. 8) pointed out that both Palaeozoic and Mesozoic *Spiriferina* have a euseptum and do not possess a true delthyrial plate.

The transverse plate is formed from lateral thickenings of the dental lamellae joining the median septum.

NORTH divided the Carboniferous species of *Spiriferina* into *Spiriferina s. s.* and *Punctospirifer*. He distinguished these genera on their external form and the form of the jugum. Permian species were excluded from this revision. The external characters of the Spitsbergen species resemble *Spiriferina* in NORTH's sense rather than *Punctospirifer*.

Spiriferina cristata (SCHLOTHEIM 1816)

?1845 *Spirifer octoplicatus* ROBERT, (not SOWERBY), pl. 19, fig. L.
?1850 *Spirifer cristatus* var. DE KONINCK, p. 640, figs. 6a–b.
?1875c *Spirifer cristata* var. TOULA, p. 258.
1902 *Spiriferina cristata* TSCHERNYSCHEW, p. 517, pl. 37, figs. 1–2.
?1914 *Spiriferina cristata* WIMAN, p. 33.
1937 *Spiriferina cristata* FREBOLD, p. 44.
1955 *Punctospirifer cristata* DUNBAR, p. 149, pl. 29, figs. 13–20.

This species appears to be uncommon in Spitsbergen. I have seen only three specimens, two complete but exfoliated shells (P. M. O. A 10014–5) from Sørkappøya, and one incomplete pedicle valve from the Brachiopod Chert of Ahlstrandodden, Bellsund. These are large specimens with the greatest width of the shell immediately anterior to the hinge line. Pedicle area high, concave, umbo narrow and pointed; cardinal extremities rounded. The folds are high and subangular, the median fold and sulcus wider than the lateral folds.

WIMAN put *Spirifer höferiana* TOULA in the synonymy of *S. cristata*. TOULA's figures of *S. höferiana* show this species to have flatter valves. The median fold has a median groove and is no larger than the lateral folds. *Spiriferina cristata* from the Zechstein is variable in form. The external characters of the Spitsbergen specimens fall into its range. However, due to the small number of specimens the internals have not been studied and it is possible that they are distinct.

Spiriferina sp. A.
Plate 22, fig. 29

1911 *Spiriferina insculpta* HOLTEDAHL, (not Phillips), p. 20. pl. 5, figs. 9–10.
1958 *Spiriferina insculpta* FORBES, (not PHILLIPS), p. 470.

There brachial valves, each with a narrow median fold and 3–4 lateral folds of similar width but lower. The surface is sculptured with imbricating concentric lamellae. Shell coarsely punctate.

This species resembles *S. insculpta* in its prominent and regular lamellae sculpture but the folds are markedly narrower.

Occurrence

Lower Gypsiferous Series, Campbellryggen (S. M. E 17236–7). Passage Beds, Sfinksen (S. M. E 18120).

HOLTEDAHL's specimens were from the Scheteligfjellet Beds, Brøggerhalvøya.

Spiriferina sp. B.

1952 *Spiriferina* sp. WANG, p. 347.

A single specimen showing the exterior of a brachial valve and a section across the pedicle umbo. This represents a large species resembling *Spiriferina nasuta* WAAGEN in size, form of the fold and coarseness of the punctation (25–30 punctae in 1 sq. mm). *S. nasuta* occurs in the Middle Productus Limestone of the Salt Range.

Upper Wordiekammen Limestone, Teltfjellet, Bünsow Land (S. M. E 17044).

Family Cyrtinidae STEHLI, 1954
Subfamily Cyrtininae FREDERICKS, 1912.

Genus *Cyrtina* DAVIDSON, 1858, p. 67.

Diagnosis

Punctospiracea with a spondylium in the pedicle valve formed from the dental lamellae and median septum. Pedicle interarea high and sometimes asymmetrical. Brachial valve shallow, with low interarea.

Genotype: *Calceola heteroclita* DEFRANCE.

Cyrtina cf. *dorsata* (M'COY)

Cf. 1844 *Cyrtia dorsata* M'COY, p. 136, pl. 22, fig. 14.
1914 *Cyrtina septosa* WIMAN (not PHILLIPS), p. 52, pl. 8, figs. 8–9, pl. 9, figs. 24–26.

Description

Outline transverse. Pedicle valve subconical with large concave, apsacline interarea and regularly convex venter without sulcus or with median flattening developing into slight depression anteriorly. Apical angle 135°–140°; delthyrial angle 35°–40°. Brachial valve slightly convex with concave orthocline interarea about 5 mm high and narrow rounded median fold. Venter and flanks of valves sculptured with simple costae, 8–9 in 10 mm in middle of their length in one specimen but coarser (5–6) in the other specimen, which also has prominent growth ridges giving valves coarsely reticulated appearance. Pedicle interarea with horizontal growth ridges and vertical lirae. Shell coarsely punctate, with 25–30 punctae in 1 sq. mm on the pedicle interarea. In pedicle valve delthyrial supporting lamellae and median septum form spondylium.

Discussion

This species differs from *C. septosa* in its less transverse form and in the absence of a sulcus. Unfortunately *C. dorsata* is a poorly known species. The only Spitsbergen specimens are those figured by WIMAN as *C. septosa*. (R. M. S. Br. 927–8). The stratigraphical horizon and locality of these specimens are unknown.

Family Rhynchospirinidae SCHUCHERT, 1894

Genus *Eumetria* HALL, 1863.

1863 *Eumetria* HALL, p. 55.
1893 *Eumetria* HALL and CLARKE, p. 115.

Diagnosis

Elongate terebratuliform punctate spiriferoids, sculptured with fine plicae. Dental lamellae and septa absent. Hinge plate of brachial valve divided into posterior and anterior parts. The former forms the socket wall and has two processes which curve posteriorly into pedicle umbo. The long, narrow concave anterior part is produced into slender crura. It is joined to posterior part by a narrow constriction. Jugum forms an elongate loop with long slender posteriorly directed median process.

Genotype: *Retzia vera* HALL.

Eumetria aff. *serpentina* (KONINCK, 1844)
Plate 22, fig. 27; text fig. 24

1914 *Eumetria serpentina* WIMAN, p. 32.

Description

Elongate oval with narrow pedicle umbo strongly incurved over brachial umbo. Valves moderately and sub-equally convex. Greatest width central. Sculpture of simple plicae, about 45 on each valve, widening towards anterior border and broadly rounded in cross section, about 25 in 5 mm on umbo, and, in a large specimen, six in 5 mm at anterior margin (20 mm from the umbo).

One specimen was serially ground (see text figure 24) but the cardinalia were found to be damaged and difficult to interpret.

Discussion

The specimens are smaller and less elongated than *E. serpentina*. *E. vera* is more globose.

Occurrence

Ambigua Limestone, Oswaldfjellet, Bjørnøya. (R. M. S. Br. 1012 a–e); Ambigua Limestone, Bjørnøya (R. M. S. 174 a–i). *E. serpentina* occurs in the Tournaisian of Belgium.

Genus *Hustedia* HALL and CLARKE, 1893, p. 120.

Diagnosis

Small plicate *Rhynchospirinidae* with apical pedicle foramen and incomplete pedicle collar. No dental lamellae. Jugum specialized. Shell punctate.

Genotype: *Terebratula mormoni* MARCOU.

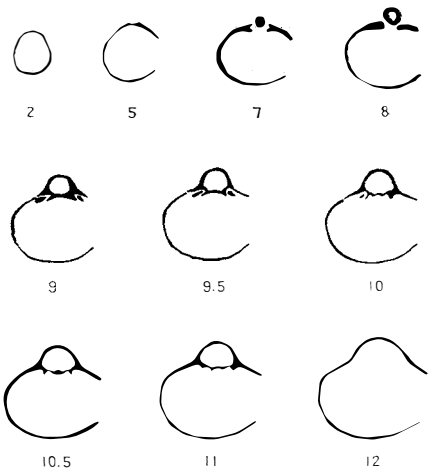

Fig. 24. *Eumetria* aff. *serpentina* (DE KONINCK). Transverse sections of R.M.S. Br. 1012 e, × 2. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

Hustedia sp. A.
Plate 22, fig. 25

Description

Outline elongate sub-triangular. Valves markedly and equally convex, without sulcus or fold. Pedicle valve with long, narrow, erect umbo. Sculpture of simple, high plicae, steep-sided with rounded crests, numbering eight on pedicle valve; interplical sulci flat-bottomed and wider than plicae.

Discussion

This species is represented by a single specimen (P. M. O. A 26331) from the Cyathophyllum Limestone of Högbomfjellet, Tempelfjorden. The plicae are similar in form to those of *Hustedia remota* (EICHWALD) but the shell is narrower and the umbo more elongated than in that species.

Hustedia sp. A may be conspecific with specimens recorded from the Cyathophyllum Limestone by HOLTEDAHL (1913, p. 26) as *Hustedia remota*.

Hustedia? sp. B.
Plate 22, fig. 26

Four specimens from the base of the Passage Beds on Sfinksen contain several valves of a *Hustedia?* sp. (S. M. E 18116–9, E 18137–42). These are rounded triangular in outline with eight or more high angular plicae diverging from the umbo and curving laterally. The form of the umbones is obscure. One specimen was serially ground, but this proved to be incomplete and distorted and showed no internal structures.

Suborder TEREBRATULOIDEA MUIR-WOOD, 1955
Superfamily Terebratulacea WAAGEN, 1883
Family Dielasmatidae SCHUCHERT and LEVENE, 1929

Genus *Dielasma* KING, 1859

1850 *Epithyris* KING, (not PHILLIPS), p. 146.
1859 *Dielasma* KING, p. 519.
1956 *Dielasma* STEHLI, p. 301.

Diagnosis

Smooth terebratuloids with rounded contours. Pedicle valve normally with flattened or sulcate venter; pedicle foramen epithyrid. Pedicle valve interior with delthyrial supporting plates; brachial valve interior with hinge plate forming sessile septalium, attached to socket plate and floor of valve in mid-line but with no other attachment.

Genotype: *Terebratulites elongatus* SCHLOTHEIM.

Discussion

STEHLI (1956) has shown that *Dielasma* has an external homoeomorph *Beecheria*, the difference between these two genera being in the form of the cardinalia of the brachial valve.

In four of the following species the cardinalia are seen to be of the *Dielasma* type. The other two do not show the brachial cardinalia and cannot be assigned to *Dielasma* with certainty.

Dielasma giganteum TSCHERNYSCHEW
Plate 25, figs. 1–4

1902 *Dielasma giganteum* TSCHERNYSCHEW, p. 455, pl. 4, figs. 1–3.

Description

Large, elongate-oval to sub-rectangular in outline; greatest thickness central. Pedicle valve flattened, curved longitudinally, with broad, sub-angular sulcus. Umbo incurved, damaged. Palintrope wide. Brachial valve more convex than pedicle valve, with sub-angular median fold. Umbo pointed. Anterior commissure uniplicate.

Pedicle valve interior with dental plates. Brachial valve interior with large, shallow septalium, elongate in outline, pointed posteriorly and broadly rounded anteriorly, with fine median groove, and marked by growth lines from which can be traced no attachment other than to floor of valve and socket plates.

Discussion

The specimens are internal moulds, damaged in the umbonal region to show the internal structures described above. They are not so large as those figured by TSCHERNYSCHEW and resemble *D. curvatum* TSCHERNYSCHEW except that the latter

species appears to have a smaller palintrope and a less sulcate pedicle valve. *D. timanicum* TSCHERNYSCHEW is another similar species but has a more quadrate outline.

Occurrence

Upper Cyathophyllum Limestone, Tempelfjorden, Skedvifjella (P. M. O. A 26289–90, A 26294); Bünsow Land, Meakinsfjellet (P. M. O. A 26413?).

Dielasma plica (KUTORGA, 1842)
Plate 25, figs. 5–12

1874 *Terebratula hastata* var. TOULA, p. 268, pl. 1, figs. 1a–g.
1902 *Dielasma plica* TSCHERNYSCHEW, p. 456, pl. 2, figs. 3–4, pl. 4, figs. 5–7.
1914 *Dielasma plica* WIMAN, p. 24, pl. 1, figs. 1–8.
1937a *Dielasma moelleri* STEPANOV, (not TSCHERNYSCHEW), p. 159, pl. 9, fig. 14.
1937 *Dielasma* sp. FREBOLD, p. 51.
1939 *Dielasma plica* EINOR, pl. 29, figs. 9a–d (reproduction of KUTORGA's original figures).
1958 *Dielasma plica* FORBES, p. 475.

Description

Outline slightly elongate-oval or sub-circular, greatest thickness central. Valve sub-equal in convexity. Pedicle valve moderately convex with umbo inflated and strongly incurved over brachial umbo. Venter flattened, internal moulds show prominent median groove; shallow sulcus sometimes developed near anterior border. Brachial valve convex, sub-circular in outline with rounded median fold. Anterior commissure uniplicate. Pedicle valve interior with prominent dental plates and collar in umbo; brachial valve with sessile septalium joining socket plates to mid-line of floor of valve.

Discussion

The specimens from the Spirifer Limestone of Sørkappøya, recorded as *Dielasma* sp. by FREBOLD (1937) are smaller, and the sulcus and fold less marked, than typical specimens of *D. plica*. They may represent a distinct species but more probably are young specimens of *D. plica*.

Occurrence

D. plica occurs throughout the Permian of Svalbard. Cora Limestone, Bjørnøya, Ymerdalen (R. M. S. Br. 989, Br. 102282–4); Upper Cyathophyllum Limestone, Spitsbergen, Kapp Schoultz (P. M. O. A 26341); Tyrrellfjellet (S. M. E 17342); Hornsund, Hyrnefjellet (P. M. O. A 28334); Spirifer Limestone, Skansbukta (S. M. E 18421–3); Tyrellfjellet (S. M. E 17616); Gipshuken (S. M. E 18787); Gipsvika, scree (S. M. E 18874); Templet (S. M. E 17415–6); Bjonahamna (S. M. E 18536); Sørkappøya (P. M. O. A 9769–74. A 10007–12); Middle Brachiopod Chert, Bellsund. Reinodden (P. M. O. A 28328).

Dielasma aff. *truncatum* WAAGEN, 1882
Plate 25, figs. 13–16

Description

Elongate oval in outline, greatest thickness central. Valves sub-equally convex. Pedicle valve moderately curved longitudinally, with broad, flattened or slightly sulcate venter, sharply flexed postero-laterally into palintrope. Pedicle umbo large, inflated, and strongly incurved over brachial umbo. Brachial valve with flat venter, gently concave in anterior third. Flanks convex, steepening laterally. Lateral commissure curving ventrally; anterior commissure uniplicate. Interior with long dental plates and hinge plate of *Dielasma* type.

Discussion

This is a large *Dielasma* resembling *D. truncatum* WAAGEN but has a less convex brachial valve, the venter of which is flat, and sometimes concave, in the anterior third.

FREDERICKS (1931) described *D. truncatum borealis* from the Kharaulakh mountains of east Siberia and later (1934, p. 13) from the Kanin Peninsula. However, the specimen figured by FREDERICKS (1934, pl. 5, fig. 16) is too poorly preserved to be compared with the present species.

Occurrence

Dielasma aff. *truncatum* occurs in the Spirifer Limestone of Bünsow Land, Tyrellfjellet (S. M. E 18699); Gipshuken (P. M. O. H 4929, H 4929 a); Bjonahamna (S. M. E 18523–35, E 18537–9).

Dielasma tschernyscheffi (GRABAU)
Plate 25, figs. 20–22; text fig. 25

1902 *Hemiptychina* (*Beecheria*) *sublaevis* TSCHERNYSCHEW, (not WAAGEN), p. 40. pl. 60, figs. 1a–d.
1914 *Hemiptychina sublaevis* WIMAN, (not WAAGEN), p. 26.
1931 *Beecheria tschernyscheffi* GRABAU, p. 86.

Description

Outline slightly elongate-oval. Pedicle valve with median ridge, roof-shaped in cross section, and with prominent umbo bent almost at right angles to rest of valve. Pedicle foramen large, epithyrid. Brachial valve flat. Valves smooth except for growth lirae or lamellae; anterior commissure recti-marginate. Internal characters studied from serial sections (text figure 25); pedicle valve with prominent dental plates in umbonal region; brachial valve with stout hinge plate forming large, sessile septalium of dielasmid type.

Discussion

Ten well-preserved specimens (R. M. S. Br. 13 a–e) from Angelinberget, Nordaustlandet were labelled by TSCHERNYSCHEW "*Hemiptychina sublaevis* WAAGEN". They resemble, in external characters, the specimen figured by TSCHERNYSCHEW (1902). However, WAAGEN's species is larger, has a more convex

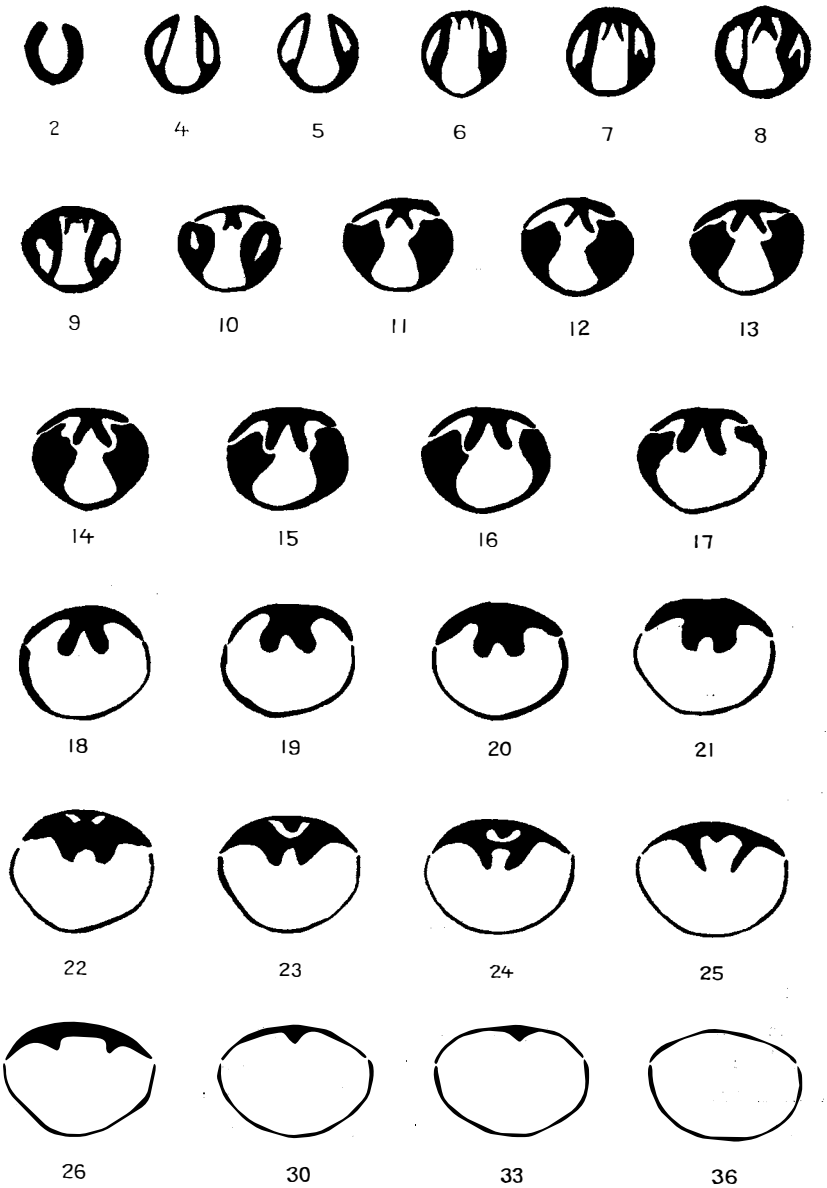

Fig. 25. *Dielasma tschernyscheffi* (GRABAU). Transverse sections of R.M.S. Br. 13 a, × 2. (The numbers refer to the position of section in hundredths of an inch, from posterior extremity of shell.)

brachial valve, a slightly uniplicate or multiplicate anterior commissure and the presence of dental plates is uncertain. GRABAU (1931) renamed TSCHERNYSCHEW's species *Beecheria tschernyscheffi*.

Dielasma? aff. *itaitubense* (DERBY, 1874)
Plate 25, figs. 17–19

1914 *Dielasma itaitubense* WIMAN, p. 25, pl. 1, figs. 9–12.

Description

Large, elongate oval to sub-circular in outline, greatest width anteriorly and greatest thickness central. Pedicle valve regularly curved longitudinally and flattened transversely, with long, narrow incurved umbo. Brachial valve more convex, sub-circular in outline with low, rounded median fold. Anterior commissure broadly uniplicate. Interior of pedicle valve with dental plates. Brachial valve cardinalia obscure.

Discussion

WIMAN's figured specimen, on which the above description is based, and three other, smaller internal moulds bear a general resemblance to *D. itaitubense* (DERBY). DERBY's figures, however, are not sufficiently clear for a detailed comparison to be made. The Svalbard form differs from the description of *D. itaitubense* given by DERBY and also from the specimens figured by WAAGEN (1882, pl. 26, fig. 5) and TSCHERNYSCHEW (1902, pl. 3, figs. 1 a–d) in having a more elongate, narrower umbo and a less convex pedicle valve.

Occurrence

Cora Limestone, Bjørnøya, Ymerdalen (R. M. S. Br. 991, S. M. E 17972–4).

Dielasma? sp.
Plate 25, figs. 23–25

Description

Elongate-oval in outline, length one and a half times width, which is greatest across middle of valves; greatest thickness central. Pedicle valve slightly more convex than brachial, with rounded venter and shallow median sulcus developed at anterior border. Brachial valve convex with median fold. Anterior commissure gently and narrowly uniplicate.

Discussion

This species is similar in size and in its elongate form to *Dielasma illinoisense* WELLER, figured by COOPER (1944, pl. 143, figs. 9–10). *D. illinoisense* occurs in the Upper Mississippian (Chester) of North America.

Occurrence

Ambigua Limestone, Bjørnøya, Oswaldfjellet (R. M. S. Br. 102372–3).

Species of doubtful occurrence or of uncertain systematic position

The Svalbard brachiopod species mentioned below were described from limited or poor material and their true identification or affinities are doubtful.

"Productus" pseudoaculeatus KROTOW

TSCHERNYSCHEW (1902, p. 359) listed this species from the Cora and Spirifer Limestones of Svalbard. Some of his figures of Russian specimens (pl. 53, figs. 10–12) resemble *Liosotella proboscidea* sp. nov. in the form and sculpture of the pedicle valve. BIRKENMAJER and CZARNIECKI (1960, p. 204) record *P. pseudoaculeatus* from the Treskelodden Beds of Hornsund.

Plicatifera? plicatiliformis FREDERICKS

1937a *Productus* (*Plicatifera?*) *plicatiliformis* STEPANOV, p. 136, pl. 2, figs. 2, 11.

STEPANOV figures two specimens from the Brachiopod Chert of Kapp Starostin and the west side of Grønfjorden.

Marginifera? bicarinata WIMAN

1914 *Marginifera? bicarinata* WIMAN, p. 78, pl. 19, figs. 12–21.

Only pedicle valve exteriors of this species are known. One pedicle valve (S. M. E 17462) shows the deep, broad sulcus and angular visceral humps characteristic of this species. It was collected from the Spirifer Limestone of Templet. WIMAN's specimens were from the Brachiopod Chert of Grønfjorden.

Paramarginifera clarkei (TSCHERNYSCHEW)

1937 *Marginifera clarkei* FREBOLD, p. 41, pl. 10, figs. 8–9.

The specimens figured by FREBOLD show only the exterior of the pedicle valve. They resemble large *Liosotella proboscidea* sp. nov. and it is doubtful that they are conspecific with *P. clarkei* (TSCHERNYSCHEW).

Cancrinella? janischewskianus STEPANOV, 1934

1936 *Productus janischewskianus* STEPANOV, p. 122, 127, pl. 1, fig. 6.
1937a *Productus* (*Linoproductus*) *janischewskianus* STEPANOV, p. 134, pl. 3, fig. 7.

This species was originally described from the Sakmarian Bryozoan Limestone of the North Ural. The Spitsbergen specimen was collected from the Brachiopod Chert of Kongressdalen, Grønfjorden.

Chonetes moelleri TSCHERNYSCHEW, 1902

TSCHERNYSCHEW identified this species in specimens (R. M. S. Br. 941–2) collected from the Spirifer Limestone of Lovénberget. Specimen Br. 941 contains three pedicle valves representing two species of brachiopods, neither of which appear to be conspecific with the specimen of *C. moelleri* figured by TSCHERNYSCHEW (1902, pl. 27, fig. 3). The specimen which most resembles *C. moelleri,* and of which Br. 942 is another example, has no interarea and resembles a juvenile *Megousia weyprechti* (TOULA).

Spiriferina höferiana TOULA

1875a *Spiriferina höferiana* TOULA, p. 135, pl. 1, figs. 1a–d.

WIMAN put this species into the synonymy of *Spiriferina cristata* (SCHLOTH.), but TOULA's figures clearly show a shell with less convex valves and a relatively lower pedicle interarea than *S. cristata*. The original specimen is lost. TOULA did not explicitly state that the shell was punctate and, if not punctate, it may have been a juvenile specimen of *Spiriferella keilhavii*.

Spiriferella cf. *verchèrei* FREDERICKS, ?not WAAGEN

1937 *Spiriferella* cf. *verchèrei* STEPANOV, p. 151, 181, pl. 8, fig. 11.

STEPANOV compared a poorly preserved internal mould with the form, from the Permian of Ussuriland, described by FREDERICKS (1925) as *Spiriferella verchèrei* WAAGEN.

IV. CORRELATION AND AGE OF THE BRACHIOPOD CHERT

Study of the stratigraphy, and of the brachiopods and fusulines occurring below the Brachiopod Chert, has shown that the latter is younger than Sakmarian. FREBOLD (1951) put the Brachiopod Chert in the upper part of the Lower Permian, DUNBAR (1955) in the Upper Permian (Zechstein), and STEPANOV (1957) in the uppermost Lower Permian and/or lower Upper Permian (Svalbardian).

These age determinations were based on brachiopods, the majority of which may be identified with, or have affinities with, species commonly occurring in the Artinskian and Kungurian of the U. S. S. R. (STEPANOV 1939). However, many of these species, e. g. *Waagenoconcha irginae* (STUCK.), *Horridonia timanica* (STUCK.), and *Cleiothyridina royssiana* (KEYS.) have long time-ranges and show considerable intraspecific variation. The Brachiopod Chert also contains the Zechstein species *Spiriferina cristata* (SCHLOTH.) and the genera *Liosotella* COOPER, *?Bathymyonia* MUIR-WOOD and COOPER, *Megousia* MUIR-WOOD and COOPER, *Licharewia* EINOR, and *Pterospirifer* DUNBAR, which are characteristic of the Upper Permian.

This mixture of faunas makes it difficult to correlate the Brachiopod Chert with other formations. It does not correspond to any of the Russian Permian stages. It could be assumed either that the Lower Permian forms existed later in Svalbard or that the Upper Permian forms appeared earlier. Thus it is convenient to follow STEPANOV and refer the Brachiopod Chert to the Svalbardian, but I think it is advisable to restrict this term, for the present, to Svalbard. The occurrence of Svalbardian brachiopods is summarized in text figure 27.

Below is a brief review of faunas from other areas which show some affinity with the Svalbardian fauna. Their distribution is shown in text figure 26.

Pinega river basin

Kazanian deposits here contain *Liosotella pseudohorrida* (WIMAN) and a *Licharewia, Spirifer voengaensis,* (LICHAREW 1931, MIRSCHINK 1938). MIRSCHINK also described *Cancrinella bolchovitinovae,* with which DUNBAR (1955) identified an east Greenland species, and which is similar to *Cancrinella spitsbergiana* sp. nov. described above.

Kanin Peninsula

FREDERICKS (1934) described a small number of species from the Kanin Peninsula. These included *Sowerbina notteiensis* FREDS. [*Liosotella pseudohorrida* (WIMAN)]; *Ruthenia granulifera* (TOULA) [*Horridonia timanica* (STUCK.)]; *R.*

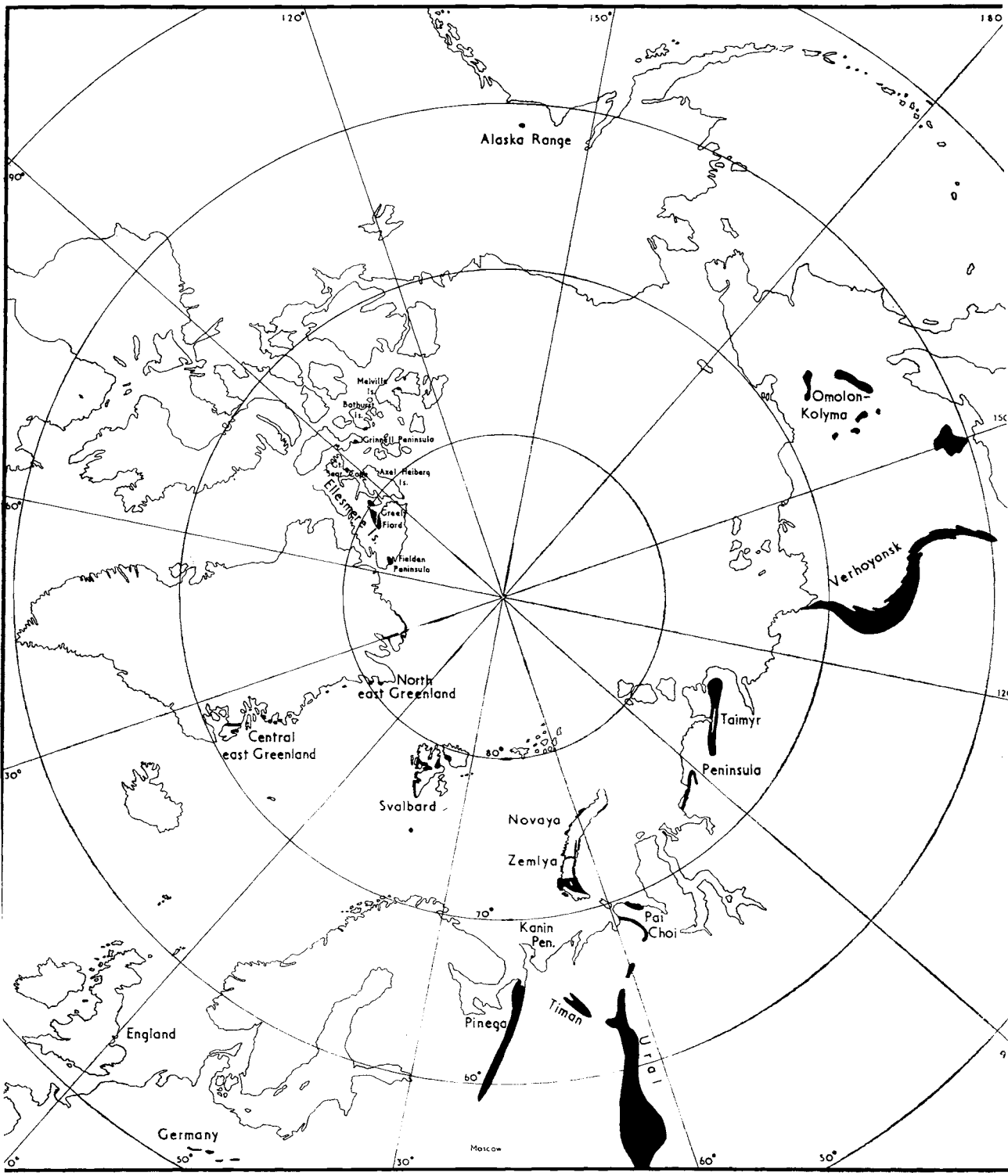

Fig. 26. Map of the Arctic, 1 : 40,000,000, showing the distribution of Permian outcrops mentioned in section IV of the text.

wimani FREDS. [*Waagenoconcha wimani* (FREDERICKS)]; and *Cleiothyridina royssiana* (KEYS.). The lamellibranchs occurring with these brachiopods have an Upper Permian character and FREDERICKS concluded that the assemblage had a Kungurian age. LICHAREW (1943) described *Spirifer kaninensis*, a species similar to *Spirifer striatoparadoxus* TOULA.

Ural and Timan

The rich Lower Permian brachiopod fauna described by TSCHERNYSCHEW (1902) has close affinities with the Lower Permian element of the Svalbardian fauna, but much of the Upper Permian lacks marine faunas. NETSCHAJEW (1911) described Kazanian brachiopods, including several species referable to *Licharewia*.

Pai Choi

The Talatinsk and Vorkutsk Series of Pai Choi contain a rich brachiopod fauna listed by USTRITSKI (1959) and described by SOLOMINA (1960). This fauna is closely comparable to the Svalbardian one and contains the following species (SOLOMINA 1960): *Streptorhynchus kempei* (WIMAN); *Liosotella pseudohorrida* (WIMAN); *Waagenoconcha wimani* (FREDS.); *W. humboldti* [*W. irginae* (STUCK.)]; *Kochiproductus porrectus* (KUT.); *Costinifera arctica* (WHIT.); *C. uralica* (TSCHERN.); *Horridonia borealis* [*H. timanica* (STUCK.)]; *Cancrinella koninckiana* (KEYS.) [cf. *Cancrinella spitsbergiana* sp. nov.]; *Muirwoodia weyprechti* [*M. duplex* (WIMAN)]; *Paeckelmannia rotunda* (TOULA) [cf. *P. permiana* (SCHUMARD)]; *Rhynchopora nikitini* (TSCHERN.); *Pseudosyrinx kolymaensis* (TOLMATSCHEW) [cf. *Pseudosyrinx wimani* sp. nov.]. These deposits were correlated with the Upper Artinskian and the Kungurian by LICHAREW (1959), but the Vorkutsk Series was to said to be of Middle to Upper Zechstein age by USTRITSKI and SOLOMINA (*fide* BIRKENMAJER and CZARNIECKI 1960, p. 207).

Novaya Zemlya

Permian brachiopods have been described from Novaya Zemlya by TOULA (1875 b), HOLTEDAHL (1924), MILORADOVICH (1935, 1936), FREDERICKS (1936) and LICHAREW and EINOR (1939). The majority of the described species are Lower Permian forms but three species of *Licharewia* are recorded from Russian Harbour. Much of the Permian is strongly folded and metamorphozed and the detailed stratigraphy is obscure. It is probable that, in most areas, the Upper Permian is missing or is represented by a continental facies. The end of the Palaeozoic marked the close of a long geosynclinal phase in Novaya Zemlya and Mesozoic deposits have not been found.

Taimyr Peninsula

Brachiopods from west Taimyr include *Licharewia* (EINOR 1939) but are otherwise more related to the Lower Permian fauna of Novaya Zemlya and the north Ural (Kolva river area) than to the Svalbardian. In Taimyr the Upper Permian is mainly continental but in the eastern part of the peninsula marine Kazanian deposits (Baikoursk Series) contain a rich brachiopod fauna (USTRITSKI 1955). This

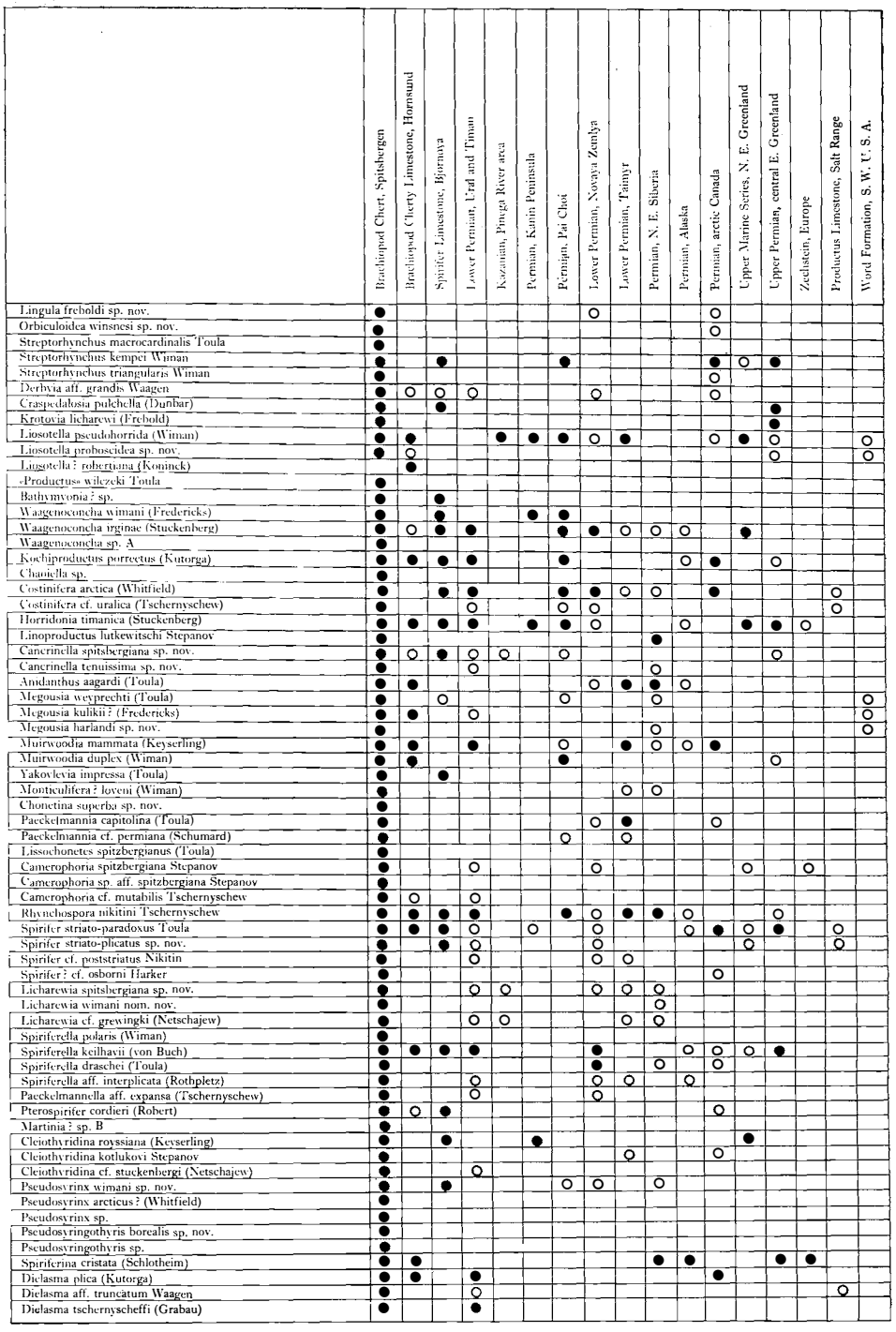

Fig. 27. Table showing the occurrence of Svalbardian brachiopods. Solid circles indicate that the species has been recorded; open circles indicate that a related species has been recorded.

includes *Liosotella pseudohorrida* (WIMAN); *Cancrinella obrutschewi* LICHAREW, which probably belongs to the genus *Monticulifera;* a *Licharewia, Spirifer* cf. *grewingki* NETSCHAJEW; and *Cleiothyridina sub-expansa* WAAGEN, a form similar to *Cleiothyridina kotlukovi* STEPANOV.

North-east Siberia

LICHAREW (1934) and KASHIRZEV (1959) have described Permian brachiopods from the Omolon-Kolyma region of north-east Siberia. Some Svalbardian genera occur in the Upper Permian of this area. LICHAREW (1934 c) noted that *"Productus" yakuticus* LICHAREW was similar to *"P". weyprechti* TOULA and, from his figures, it appears to belong to the genus *Megousia. "Productus" obrutschewi* LICHAREW was compared with *"P". lovéni* WIMAN; it has the characteristic scuplture of the genus *Monticulifera. Licharewia* is represented by 10 species, described by KASHIRZEV (1959). *Pseudosyrinx kolymaensis* (TOLMATSCHEW) resembles the Svalbardian *Pseudosyrinx wimani* sp. nov.

Ussuriland

The brachiopods from Cape Kalouzin, described by FREDERICKS (1925) include *Anidanthus aagardi* (TOULA); *"Productus" weyprechti* TOULA; *Yakovlevia;* and large spirifers, *S. striatus* mut. *neostriatus* FREDS. and *S. fasciger ambiensis* WAAGEN, which resemble respectively *S. striato-paradoxus* TOULA and *Spirifer* striatoplicatus sp. nov. However, the presence of oldhaminids shows affinity with the Pacific fauna.

Alaska

The rich Permian faunas of Alaska are almost wholly undescribed. GIRTY (in MOFFIT 1938, 1954) lists Permian brachiopods from south-east Alaska which appear to be closely related to the Lower Permian of the European part of the U. S. S. R., but include *Horridonia horrida* (SOW.) and *Spiriferina cristata* (SCHLOTH.).

Arctic Canada

Permian rocks are widespread in the Canadian Arctic but little has been published on the brachiopod they contain. *Horridonia horrida* (SOW.) and *Liosotella pseudohorrida* (WIMAN) or a closely related form, were collected by MCCLINTOCK from Hillock Point, on the north coast of Melville Island, and described by HAUGHTON (1858) as *Productus sulcatus* var. *borealis*. HAUGHTON also recorded *Spirifer arctica* sp. nov. from Hillock Point and from the north coast of Bathurst Island. *S. arctica* closely resembles *Spiriferella keilhavii* (BUCH).

The brachiopod fauna of the Assistance Formation of Grinnell Peninsula, Devon Island, was described by HARKER and THORSTEINSSON (1960). This fauna which has a Svalbardian character was correlated by these authors with the Leonard and lower Word formations of Texas.

The brachiopods from Great Bear Cape, Ellesmere Island, and the northern tip of Axel Heiberg Island, described by TSCHERNYSCHEW and STEPANOV (1916),

and those from the Fielden Peninsula described by WHITFIELD (1908), may be compared with the Lower Permian element of the Svalbardian fauna but the Upper Permian forms are absent. TROELSEN (1950) reviewed the geology of Ellesmere Island and described 700 m of Permian rocks (Greely Fjord group) from Greely and Canyon Fjords, which lie on the strike between Great Bear Cape and the Fielden Peninsula. An early form of *Schwagerina* sp. was collected from the top of the Greely Fjord Group and a Wolfcampian (Sakmarian) age was suggested for these rocks.

North-east Greenland

Brachiopods from the Upper Palaeozoic of Holms and Amdrups Land were described by GRÖNWALL (1917) who recognized continental beds overlain by a Lower and an Upper Marine Series. NIELSEN visited the area in 1938–9 and made further collections from which the brachiopods were described by FREBOLD (1950). The fauna of the Lower Marine Series is similar to that of the Middle Carboniferous of Svalbard. The disconformable Upper Marine Series contains a large percentage of Svalbardian species but, apart from *Liosotella pseudohorrida* (WIMAN), the Upper Permian element is absent.

Fusulines collected from this succession show the age of the Lower Marine Series to be Des-Moinesian (Moscovian) and the Upper Marine Series to be Wolfcampian (Sakmarian) (DUNBAR et al. 1960).

Central east Greenland

The various facies of the Permian of central east Greenland have been shown to belong to one period of deposition (MAYNC 1942). DUNBAR (1955) showed that the brachiopods had strong Zechstein affinities. He described 47 species, seven of which are present in the Svalbardian (viz. *Streptorhynchys kempei* WIMAN; *Craspedalosia pulchella* (DUNBAR); *Krotovia nielseni* DUNBAR [*K. Licharewi* FREB.]; *Sowerbina rudis* and *S. maynci* DUNBAR [*Horridonia timanica* (STUCK.)]; *Spirifer striato-paradoxus* TOULA; *Spiriferella keilhavii* (BUCH); *Spiriferina cristata* (SCHLOTH.). Another six species may be closely compared with Svalbardian forms. However, typical Lower Permian species are absent from central east Greenland. The Eo-Triassic rests conformably on the Permian and, in the basal Lower Glyptophiceras Beds, occur several species of indigenous brachiopods, crinoids and polyzoa characteristic of the underlying Permian (TRÜMPY 1960). This interesting mixture of faunas and the presence of the ammonoid *Cyclolobus* strongly suggests that the Permian of central east Greenland belongs to the uppermost part of the Period and is thus considerably younger than the Svalbardian.

South-western U. S. A.

The Svalbardian has little in common with the Permian of trans-Pecos Texas except that the genus *Megousia* occurs in the Leonard and Word formations of the Glass Mountains. *Megousia* is also known from limestones of Word age at El Antimono, Western Sonora, Mexico, from which *Liosotella* was originally described (COOPER 1953).

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V. PLATES

Specimens are figured at natural size and coated with ammonium chloride except where stated to the contrary.

PLATE 1

Figures 1–2. *Lingula frevoldi* sp. nov., Upper Brachiopod Chert, Högskulefjellet, Dickson Land. 1, block with several valves including the holotype (S. M. E 18091); 2, holotype, × 3, uncoated with ammonium chloride.

Figure 3. *Lingula* sp., block with several valves (S. M. E 17895–901), uncoated with ammonium chloride, *ex* Campbellryggen Group, south of Kapp Scott, Billefjorden.

Figures 4–5. *Orbiculoidea winsnesi* sp. nov. 4, brachial valve, latex cast from a natural external mould (S. M. E 18280), Upper Brachiopod Chert, Studentdalen, Dickson Land; 5, pedicle valve interior, the holotype (P. M. O. A 26271), Brachiopod Chert, Skarvrypehögda, Sassenfjorden.

Figure 6. *Orbiculoidea* sp., pedicle valve interior (S. M. E 18302), scree *ex* Wordiekammen Limestone, Teltfjellet, Bünsow Land.

Figure 7. *Rhipidomella michelini* (L'ÉVEILLÉ), ventral view of X 633, Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land.

Figures 8–10. *Orthotichia* cf. *morganiana* (DERBY), respectively ventral, lateral, and dorsal views of S. M. E 18128, Passage Beds, Sfinksen, Billefjorden.

Figures 11–13. *Schuchertella* cf. *rovnensis* YANISCHEVSKY, Tårnkanten Sandstone, Oscar II Land, 11, brachial valve, Tårnkanten; 12, pedicle valve, latex cast of natural external mould (X 637). Robertsonfjellet; 13, pedicle valve (X 611), Tårnkanten.

Figures 14–15. *Streptorhynchus triangularis* WIMAN, respectively exterior and interior of pedicle valve (X 643), Brachiopod Limestone, Skivefjellet, Oscar II Land.

Figures 16–17. *Meekella* cf. *timanica* TSCHERNYSCHEW, respectively interarea and exterior of pedicle valve (S. M. E 18413), *ex* Cyathophyllum Limestone, station W 139, Oslobreen, Ny Friesland.

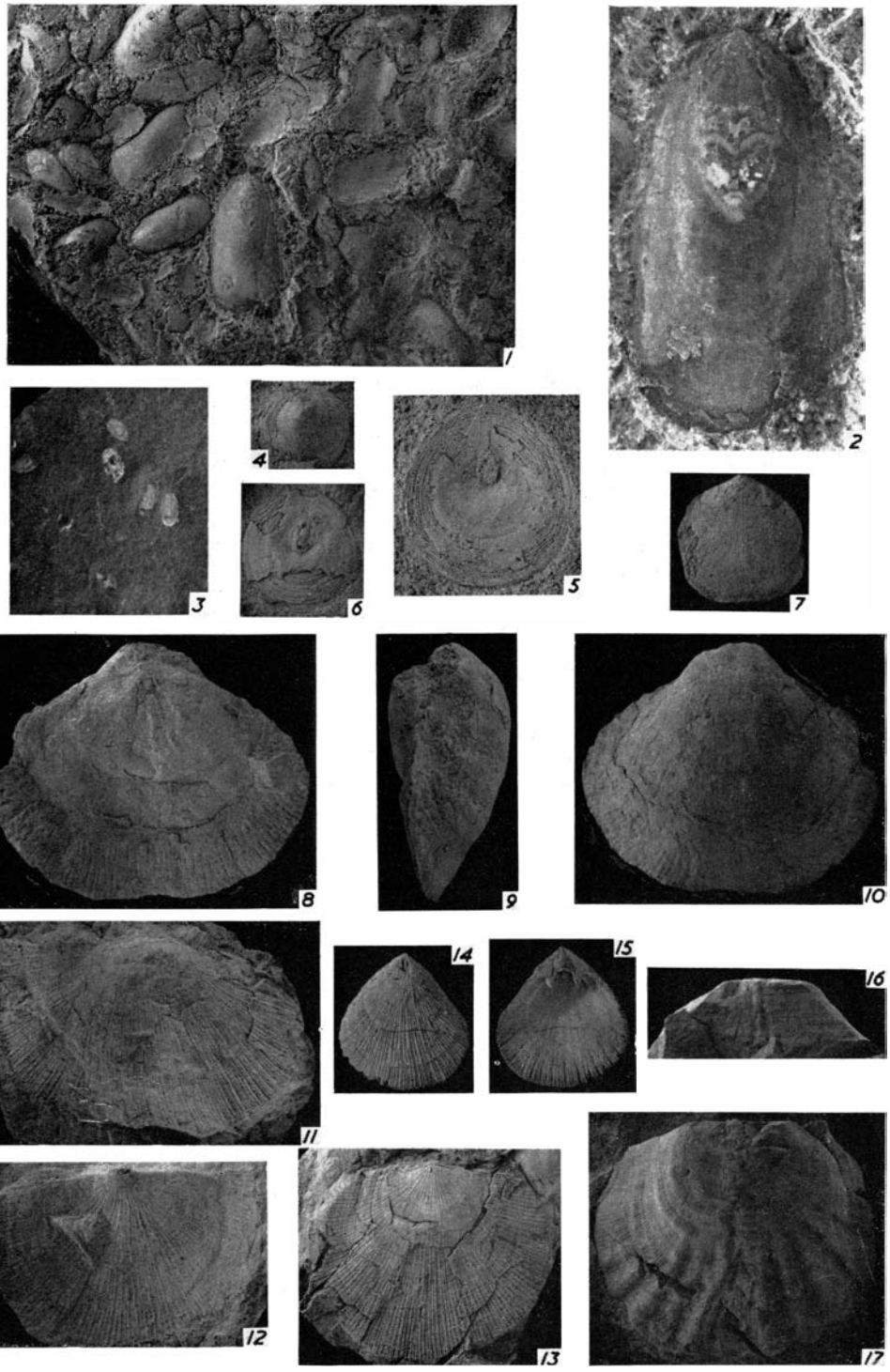
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PLATE 2

Figures 1–2. *Derbyia* aff. *grandis* WAAGEN, respectively interarea and exterior of pedicle valves, (S. M. E 18522), Spirifer Limestone, Bjonahamna, Tempelfjorden.

Figure 3. *Streptorhynchus kempei* WIMAN, dorsal view of S. M. E 18618, Spirifer Limestone, Bjonahamna, Tempelfjorden.

Figures 4–5. *Streptorhynchus macrocardinalis* TOULA, respectively exterior and interior of pedicle valve (S. M. E 18217), Spirifer Limestone, mouth of Sassendalen, Tempelfjorden.

Figures 6–10. *Craspedalosia pulchella* (DUNBAR). 6–7, respectively ventral and lateral views of natural internal mould (S. M. E 17914), Spirifer Limestone, Herwighamna, Bjørnøya; 8–9, respectively interior and lateral views of silicified brachial valve (S. M. E 17924), Spirifer Limestone, Lundenæringane, Bjørnøya; 10, interior of brachial valve showing pedicle valve teeth *in situ* (P. M. O. A 9997), Brachiopod Chert, Sørkappøya.

Figures 11–12. *Aulosteges* sp., respectively pedicle interarea and ventral view of natural internal mould (S. M. E 17323), Upper Wordiekammen Limestone, Tyrellfjellet, Bünsow Land.

Figures 13–18. *Sinuatella sinuata* (DE KONINCK), Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land. 13–14, respectively ventral and lateral views of pedicle valve (X 631); 16–17, the same, × 2; 15, lateral view of another pedicle valve (X 631); 18, the same, ×2.

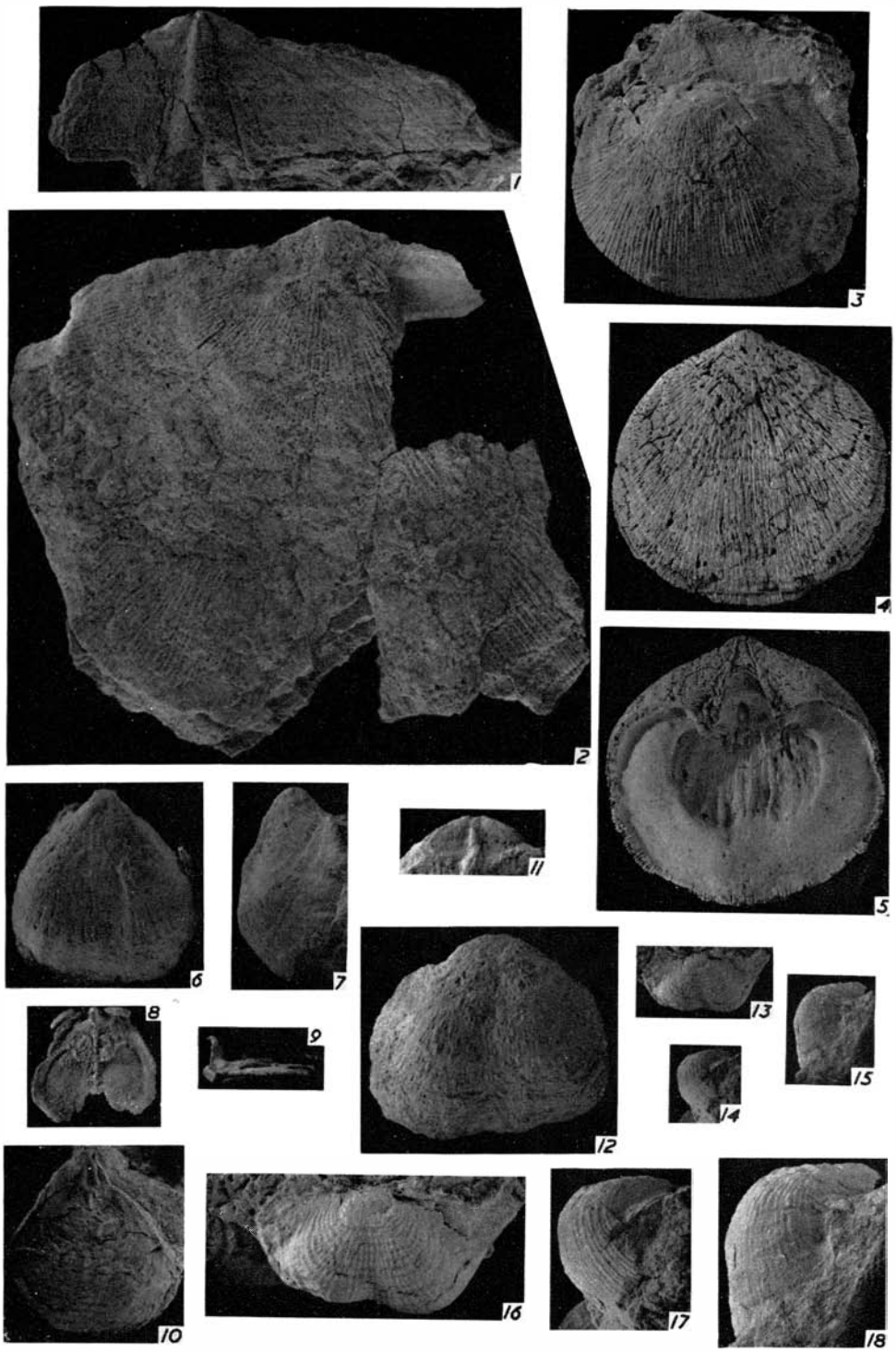
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PLATE 3

Figures 1–10. *Krotovia licharewi* (FREBOLD), Middle Brachiopod Chert, Gipshuken, Bünsow Land. 1, ventral view of pedicle valve (S. M. E 17727); 2, the same, ×2; 3–4, respectively dorsal and lateral views of S. M. E 17731; 5–6, the same, ×2; 7–8, respectively ventral and dorsal views of S. M. E 17728; 9–10, the same, ×2.

Figures 11–20. *Eomarginifera longispina* (J. SOWERBY), Tårnkanten Sandstone, Tårnkanten, Oscar II Land. 11–12, respectively anterior and lateral views of X 609.1; 13–14, the same, ×2; 15, lateral view of pedicle valve (X 609.2); 16, the same, ×2; 17, ventral view of pedicle valve (X 609.3); 18, the same, ×2; 19, dorsal view of natural internal mould (X 609.2); 20, the same, ×2.

Figures 21–26. *Marginifera?* cf. *schellwieni* TSCHERNYSCHEW. 21, anterior view of pedicle valve (S. M. E 17077), Upper Wordiekammen Limestone, Teltfjellet, Bünsow Land; 22, the same, ×2; 23, lateral view of pedicle valve (S. M. E 17078), Upper Wordiekammen Limestone, Teltfjellet; 24, the same, ×2; 25, brachial valve, natural external mould (S. M. E 17024), Middle Wordiekammen Limestone, Teltfjellet; 26, the same, ×2.

Figures 27–34. *Liosotella pseudohorrida* (WIMAN). 27–29, respectively ventral, posterior, and dorsal views of S. M. E 18059, Brachiopod Chert, Cepheusfjellet, Polarisbreen, Ny Friesland; 30–32, respectively ventral, posterior, and dorsal views of S. M. E 17702, Middle Brachiopod Chert, Gipshuken, Bünsow Land; 33–34, brachial valve interiors, respectively S. M. E 17685 and E 17703, Middle Brachiopod Chert, Gipshuken.

Figures 35–41. *Liosotella proboscidea* sp. nov., Middle Brachiopod Chert, Gipshuken, Bünsow Land. 35–37, respectively ventral, dorsal, and lateral views of the holotype (S. M. E 17707); 38–40, respectively ventral, posterior, and anterior views of pedicle valve, paratype (S. M. E 17704); 41, dorsal view of paratype (S. M. E 17701).

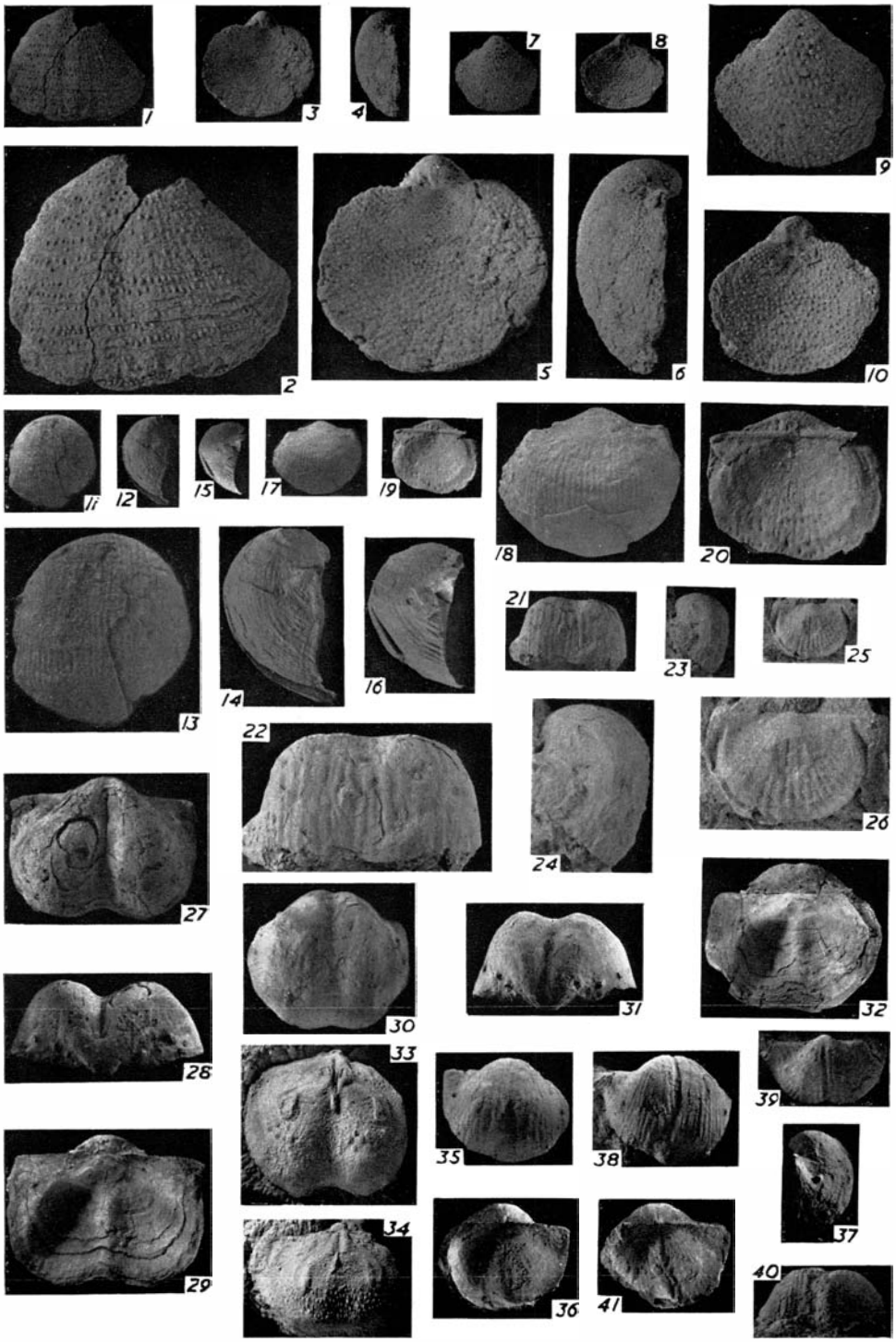
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PLATE 4

Figures 1–7. *Liosotella? robertiana* (DE KONINCK). 1–3, respectively anterior, ventral, and lateral views of pedicle valve (B. M. 65001), Bellsund; 4–6, the same, ×2; 7, anterior view of P. M. O. A 9803.

Figures 8–14. *Probolionia involuta* (TSCHERNYSCHEW), Cora Limestone, Ymerdalen, Bjørnøya. 8–10, respectively ventral, lateral, and anterior views of pedicle valve (S. M. E 17956); 11–12, respectively ventral and dorsal views of S. M. E 17961); 13, counterpart of figure 12; 14, brachial valve interior (S. M. E 17948).

Figures 15–27. *Productus anderssoni* sp. nov., Ambigua Limestone, Bjørnøya. 15–16, respectively anterior and lateral views of pedicle valve, paratype (R. M. S. Br. 1344 a), Oswaldfjellet; 17, trail of pedicle valve, paratype (R. M. S. Br. 1344 d), Oswaldfjellet; 18–21, respectively posterior, ventral, lateral and anterior views of pedicle valve, the holotype (R. M. S. Br. 1342 c), north-west of Ellasjøen; 22, figure 18, ×2; 23, ventral view of pedicle valve, paratype (R. M. S. Br. 1344 f), Oswaldfjellet; 24, the same, ×2; 25, natural external mould of brachial valve, paratype (R. M. S. Br. 1344 c), Oswaldfjellet; 26, the same, ×2; 27, trail of brachial valve, paratype (R. M. S. Br. 1344 l), Oswaldfjellet.

Figures 28–32. *Echinoconchus? isachseni* (HOLTEDAHL). 28–30, respectively ventral, lateral, and anterior views of pedicle valve (S. M. E 17980), Ambigua Limestone, north of Kapp Kåre, Bjørnøya; 31–32, respectively ventral and anterior views of pedicle valve (P. M. O. A 4109) figured by HOLTEDAHL (1911, pl. 2, fig. 3) as *Productus irginae,* Scheteligfjellet Beds, Scheteligfjellet, Brøggerhalvøya.

Figure 33. *Pustula* cf. *mosquensis* (IVANOV), natural internal mould of pedicle valve (S. M. E 17906), Lower Gypsiferous Series, Ebbadalen, Billefjorden.

Figures 34–37. *Juresania juresanensis* (TSCHERNYSCHEW), Upper Wordiekammen Limestone, Gipsvika, Bünsow Land. 34–35, respectively ventral and lateral views of pedicle valve (S. M. E 17389); 36–37, ventral views of respectively pedicle and brachial valves (S. M. E 18264).

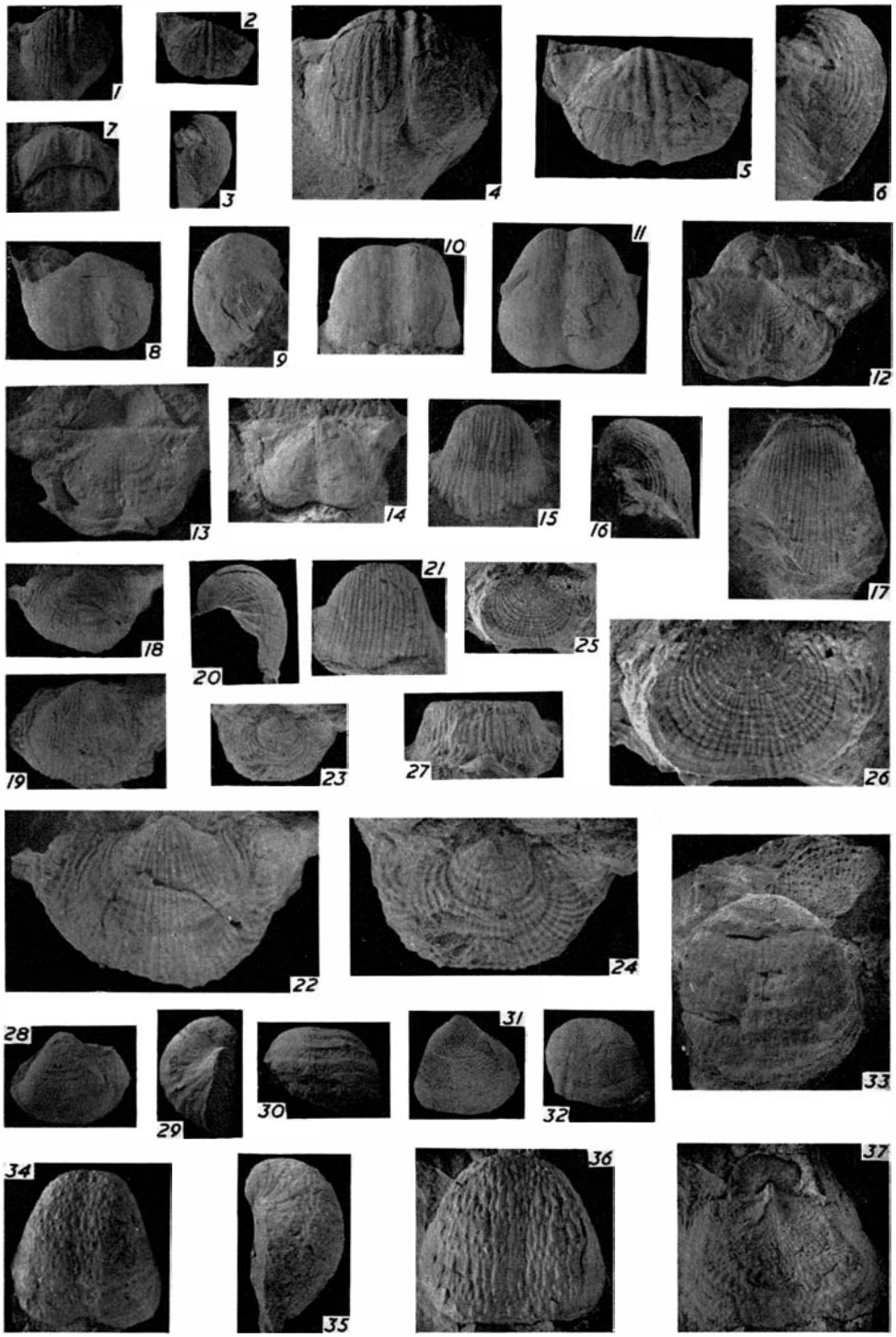
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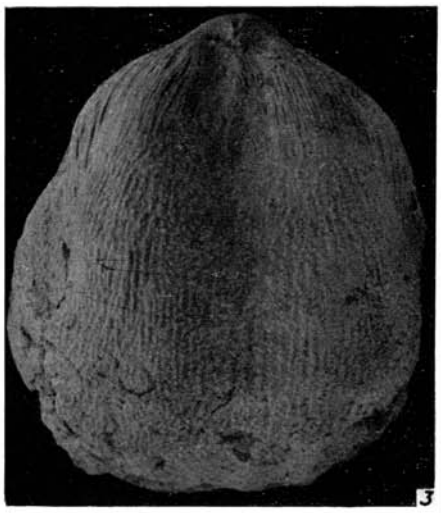
PLATE 5

Figures 1–2. *Waagenoconcha wimani* (FREDERICKS), respectively ventral and lateral views of pedicle valve (S. M. E 17922), Spirifer Limestone, Lundenæringane, Bjørnøya.

Figures 3–5. *Bathymyonia?* sp. 3, internal mould of pedicle valve (B. M. B 85024), Brachiopod Chert, Akseløya?, Bellsund; 4, brachial valve interior (S. M. E 18455), Spirifer Limestone, Bjonahamna, Tempelfjorden, uncoated with ammonium chloride; 5, pedicle valve exterior, latex cast taken from a natural external mould (D. Q 13), Spirifer Limestone, Garwoodtoppen, Kongsfjorden.

Figure 6. *Waagenoconcha* sp. B., latex cast of brachial valve exterior taken from a natural external mould (S. M. E 18190), Lower Wordiekammen Limestone, Teltfjellet, Bünsow Land.

Figure 7. *Waagenoconcha irginae* (STUCKENBERG), latex cast of brachial valve exterior taken from a natural external mould (R. M. S. Br. 1296), Cora Limestone, Ymerdalen, Bjørnøya.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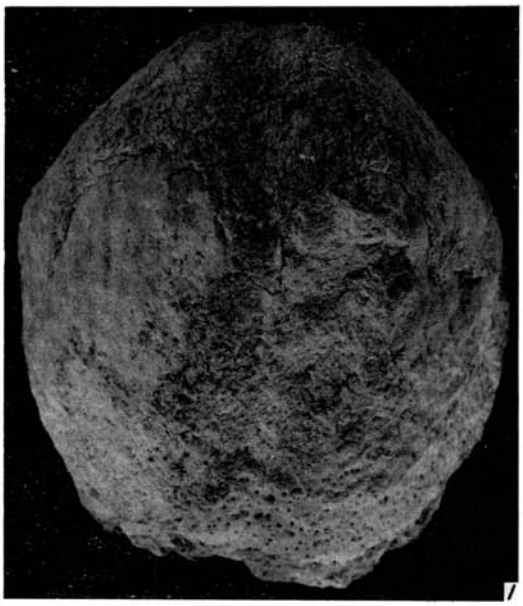
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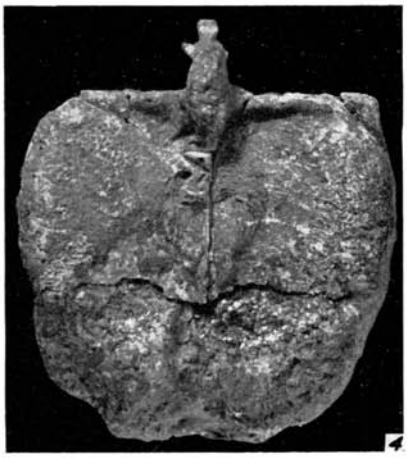
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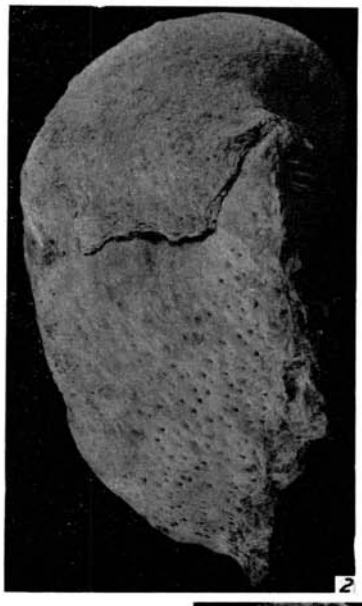
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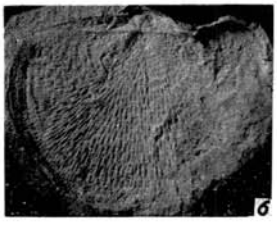
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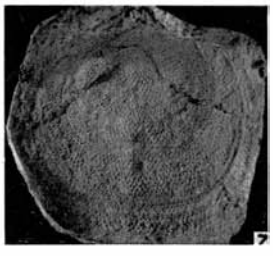
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PLATE 6

Figures 1–5. *Waagenoconcha irginae* (STUCKENBERG), Spirifer Limestone, Bünsow Land, uncoated with ammonium chloride. 1–3, respectively dorsal, lateral and ventral views of S. M. E 17496, Usherfjellet; 4, dorsal view of S. M. E 18647, Bjonahamna; 5, brachial valve interior (S. M. E 18642), Bjonahamna.

Figures 6–8. *Waagenoconcha* sp. A, respectively posterior, ventral, and anterior views of P. M. O. A 26260, Brachiopod Chert, Rejmyrefjellet, Tempelfjorden. Uncoated with ammonium chloride.

Figure 9. *Bathymyonia?* sp., brachial valve interior (S. M. E 17923), Spirifer Limestone, Lundenæringane, Bjørnøya. Uncoated with ammonium chloride.


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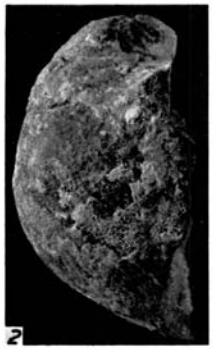
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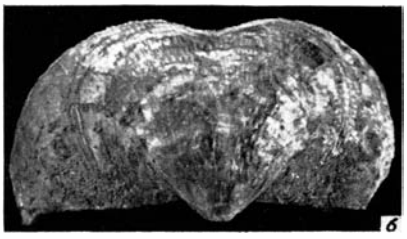
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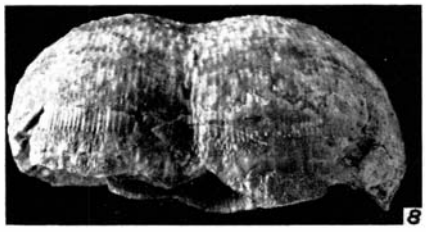
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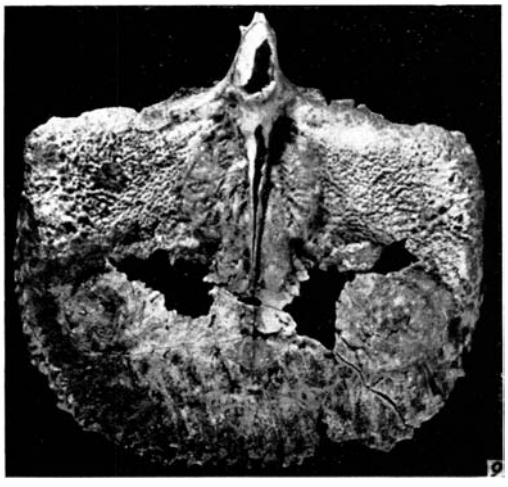
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PLATE 7

Figures 1–3. *Kochiproductus porrectus* (KUTORGA), Spirifer Limestone, Bjonahamna, Tempelfjorden. Uncoated with ammonium chloride. 1, dorsal view (S. M. E 18505); 2, brachial valve interior (S. M. E 18502); 3, ventral view of pedicle valve (S. M. E 18497).

Figures 4–6. *Antiquatonia* cf. *serenensis* SARYCHEVA. 4–5, respectively ventral and anterior views of pedicle valve (X 630), Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land; 6, lateral view of pedicle valve (S. M. E 17208), Passage Beds, Jacksonfjellet, Billefjorden.

Figures 7–9. *Antiquatonia prikschiana* (YANISCHEVSKY), Tårnkanten Sandstone, Oscar II Land. 7,9 respectively anterior and lateral views of pedicle valve (X 629.1), Robertsonfjellet; 8, trail of pedicle valve (X 615), Jutulslottet.

Figures 10–11. *Buxtonia* sp., respectively ventral and anterior views of pedicle valve (X 628.2), Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land.

Figures 12–13. *Chaoiella?* cf. *taiyuanfuensis* (CHAO), respectively lateral and ventral views of pedicle valve (S. M. E 17071), Upper Wordiekammen Limestone, Teltfjellet, Bünsow Land.

Figures 14–15. *Pugilis* sp., Tårnkanten Sandstone, Oscar II Land. 14, trail of pedicle valve (X 693.2); 15, ventral view of pedicle valve (X 693.1).

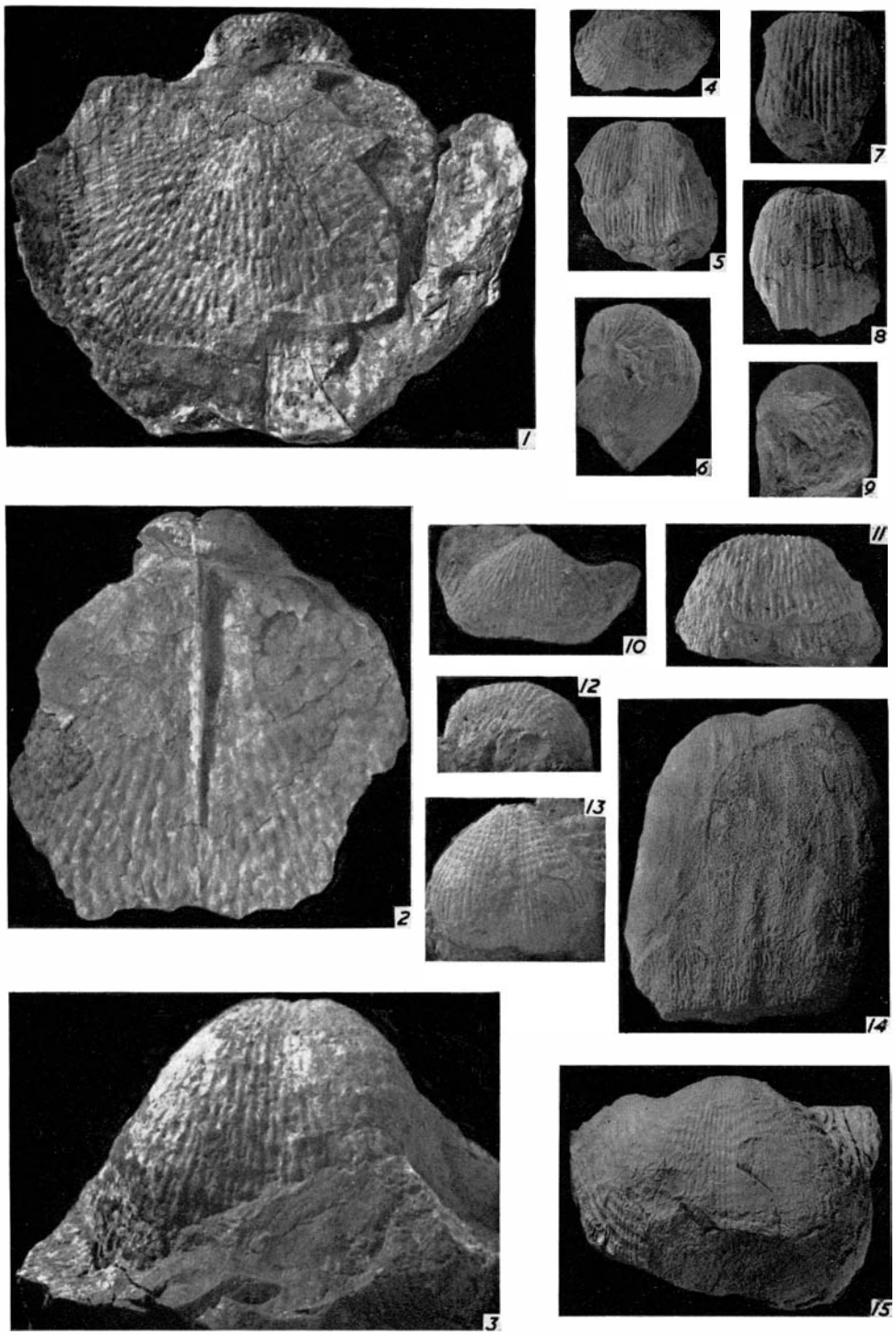
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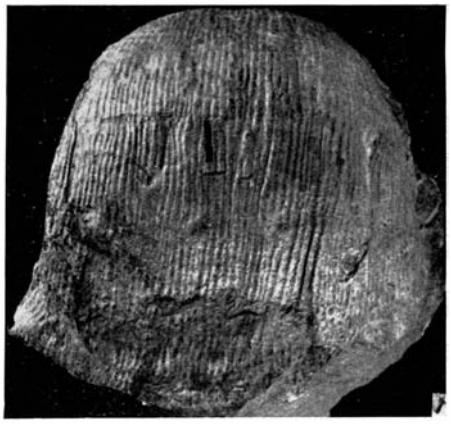
PLATE 8

Figures 1–5. *Reticulatia holtedahli* sp. nov., Passage Beds, shore at mouth of Ebbadalen, Billefjorden. Uncoated with ammonium chloride. 1–3, respectively trail, lateral, and ventral views of pedicle valve, the holotype (S. M. E 18723); 4, dorsal view of paratype (S. M. E 17227); 5, exfoliated brachial valve interior, paratype (S. M. E 18729).

Figure 6. *Dictyoclostus?* aff. *inflatiformis* IVANOV, ventral view of complete specimen (S. M. E 17988), Ambigua Limestone, north of Kapp Kåre, Bjørnøya. Uncoated with ammonium chloride.

Figures 7–9. *Chaoiella* cf. *grünewaldti* (KROTOW), respectively ventral, lateral, and anterior views of pedicle valve (S. M. E 17967), Cora Limestone, Ymerdalen, Bjørnøya.

Figures 10–11. *Reticulatia* cf. *moelleri* (STUCKENBERG), respectively ventral and lateral views of S. M. E 18272, scree, Watsondalen, Bünsow Land. Uncoated with ammonium chloride.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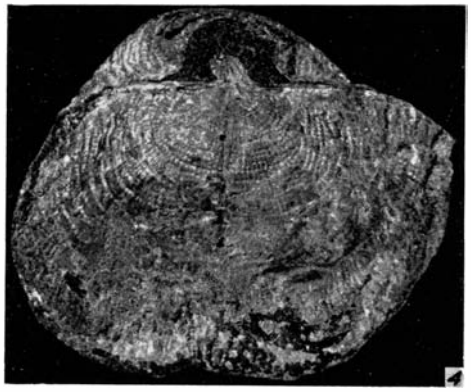
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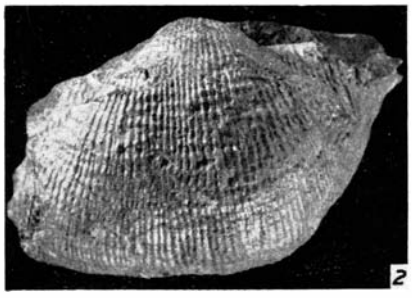
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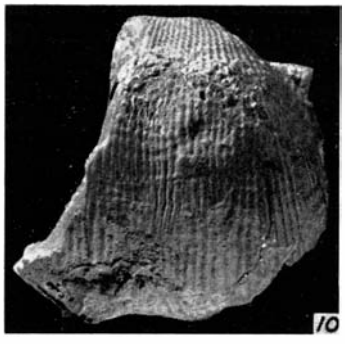
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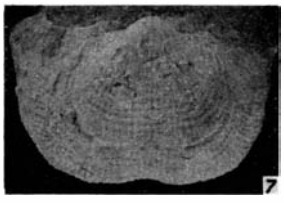
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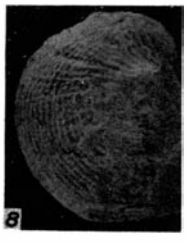
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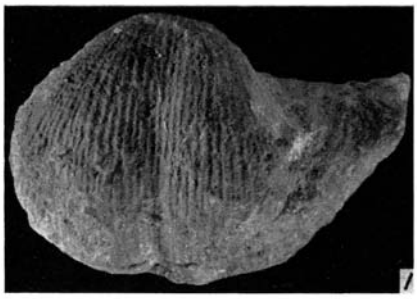
PLATE 9

Figure 1. *Chaoiella?* sp., ventral view of pedicle valve (S. M. E 17503), Spirifer Limestone, Gipshuken, Bünsow Land. Uncoated with ammonium chloride.

Figures 2–6. *Costinifera arctica* (WHITFIELD), Spirifer Limestone, Uncoated with ammonium chloride. 2–3, respectively ventral and lateral views of pedicle valve (S. M. E 18512), Bjonahamna, Tempelfjorden; 4–5, respectively anterior and ventral views of pedicle valve (S. M. E 18509), Bjonahamna; 6, anterior view of complete specimen (X 640), showing part of brachial valve trail, Skivefjellet, Oscar II Land.

Figure 7. *Costinifera* cf. *uralica* (TSCHERNYSCHEW), ventral view of crushed and exfoliated pedicle valve (B. M. BB 23440), Spirifer Limestone, Kapp Starostin, Isfjorden.

Figure 8. *Reticulatia* cf. *moelleri* (STUCKENBERG), natural external mould of brachial valve (S. M. E 18115), scree ex Wordiekammen Limestone, Wordiekammen, Billefjorden.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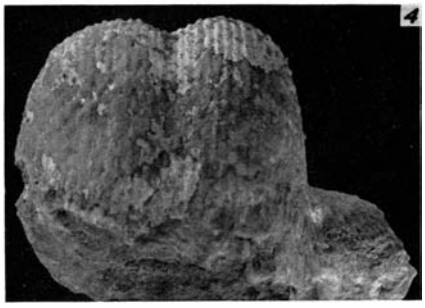
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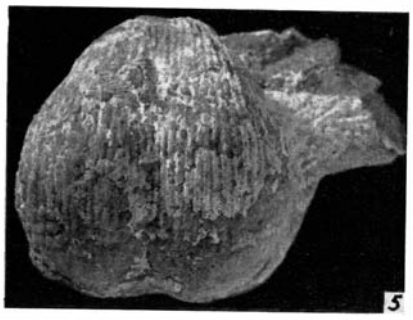
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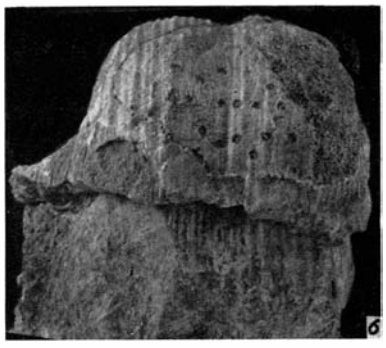
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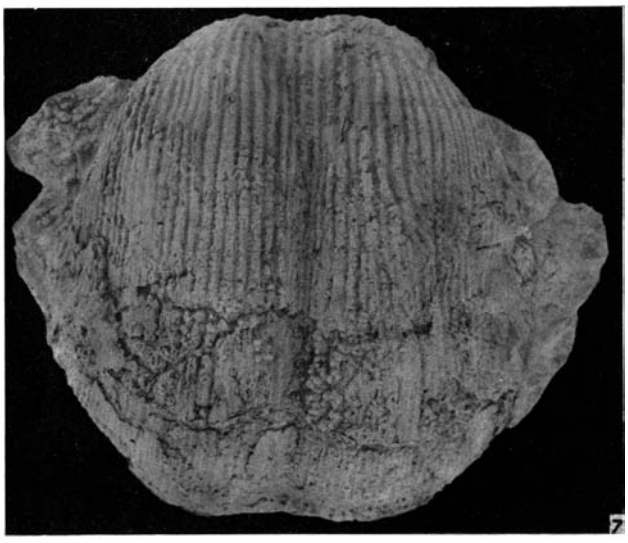
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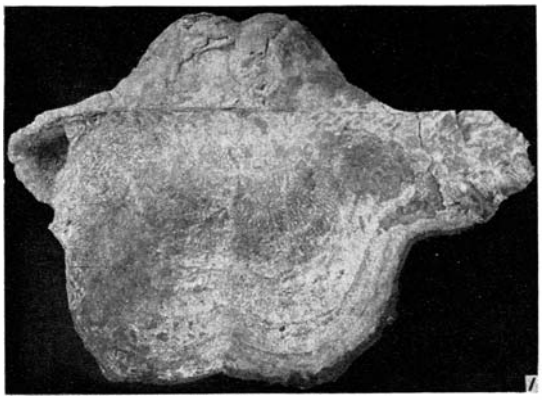
PLATE 10

Figures 1–4. *Horridonia timanica* STUCKENBERG, Spirifer Limestone: uncoated with ammonium chloride. 1, dorsal view of S. M. E 17833, Templet, Bünsow Land; 2, lateral view of S. M. E 17832, Templet; 3, ventral view of S. M. E 17817, Templet; 4, ventral view of pedicle valve (S. M. E 17831), Kapp Wijk, Dicksonfjorden.

Figures 5–7. *Horridonia geniculata* sp. nov., respectively ventral, lateral, and anterior views of the holotype (S. M. E 17978), Cora Limestone, Ymerdalen, Bjørnøya.

Figures 8–9. *Linoproductus dorotheevi* (FREDERICKS), respectively dorsal and ventral views of S. M. E 18270, Upper Wordiekammen Limestone, Tyrrellfjellet, Bünsow Land.

Figures 10–11. *Striatifera?* sp., exfoliated pedicle valves, Transition Beds, Odellfjellet. 10, S. M. E 18760; 11. S. M. E 18755.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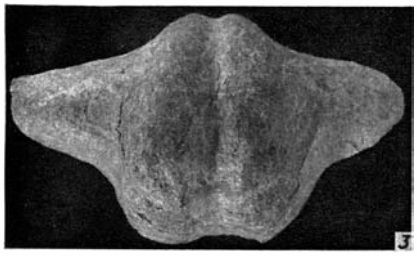
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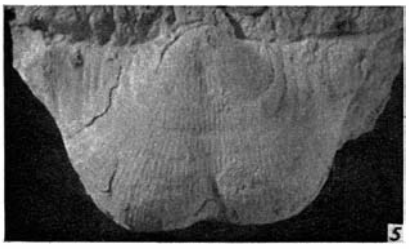
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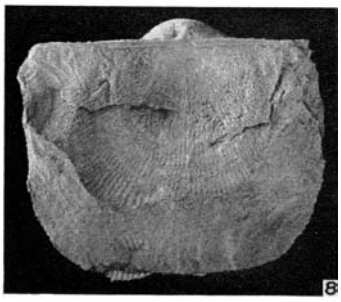
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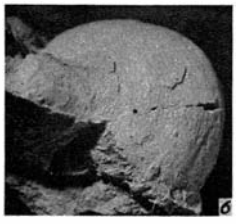
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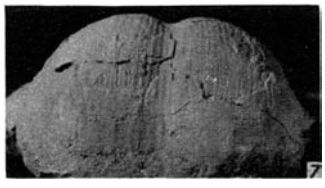
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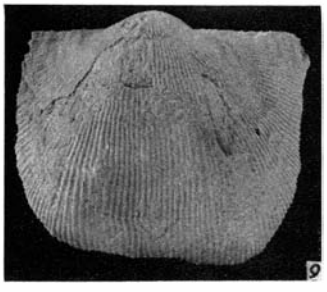
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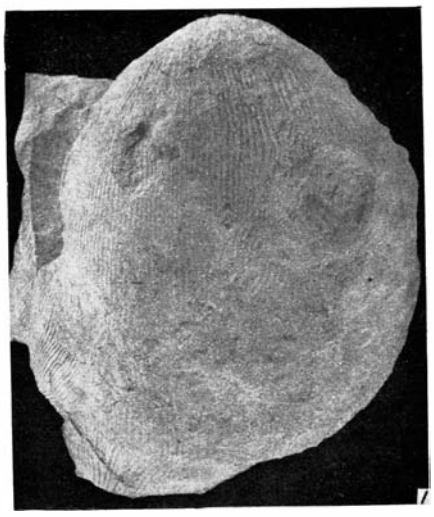
PLATE 11

Figures 1–5. *Linoproductus dorotheevi* (FREDERICKS). 1, ventral view of pedicle valve (S. M. E 18695), Upper Wordiekammen Limestone, Tyrrellfjellet, Bünsow Land; 2, ventral view of pedicle valve (S. M. E 18376), scree, Gerardfjella, Bünsow Land; 3, exfoliated brachial valve interior (S. M. E 17320 a), Upper Wordiekammen Limestone, Tyrrellfjellet; 4, natural external mould of brachial valve (S. M. E 17330), Upper Wordiekammen Limestone, Brisingefjellet; 5, lateral view of pedicle valve (S. M. E 17074), Upper Wordiekammen Limestone, Teltfjellet, Bünsow Land.

Figure 6. *Linoproductus* sp. A, pedicle valve and displaced brachial valve (S. M. E 18114), scree *ex* Wordiekammen Limestone, Wordiekammen, Billefjorden.

Figures 7–8. *Linoproductus* sp. B, natural external moulds of pedicle valves, Transition Beds, Odellfjellet. 7, S. M. E 18765, ×2; 8, S. M. E 18770, ×2.

Figures 9–10. *Ovatia* cf. *simensis* (TSCHERNYSCHEW), Lower Gypsiferous Series, Ebbadalen, Billefjorden. 9, ventral view of pedicle valve (S. M. E 17904); 10, exfoliated brachial valve interior (S. M. E 17905).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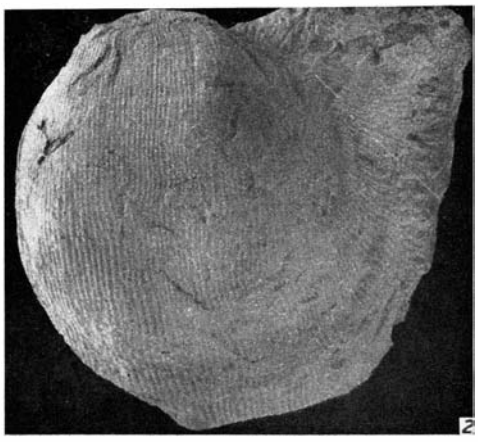
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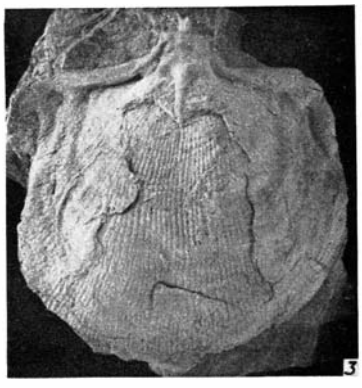
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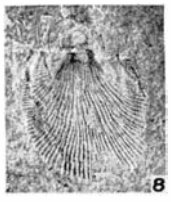
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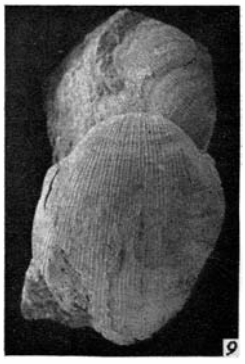
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PLATE 12

Figures 1–7. *Cancrinella singletoni* sp. nov., Upper Wordiekammen Limestone, Bünsow Land. 1, ventral view of pedicle valve, the holotype (S. M. E 18232) Gipsvika; 2–4, respectively ventral, postero-ventral, and lateral views of pedicle valve, paratype (S. M. E 18692), Tyrrellfjellet; 5, lateral view of natural external mould of brachial valve, paratype (S. M. E 18694), Tyrellfjellet; 6, natural external mould of brachial valve, paratype (S. M. E 18250), Gipsvika; 7, anterior view of the specimen shown in figure 1, enlarged ×2 to show the form of the sculpture.

Figures 8–12. *Cancrinella spitsbergiana* sp. nov., Spirifer Limestone, Bünsow Land. 8–9, respectively ventral and lateral views of ex-foliated pedicle valve (S. M. E 18487), Bjonahamna; 10, anterior view of natural internal mould of pedicle valve (S. M. E 17432), Templet; 11–12, respectively ventral and dorsal views of exfoliated specimen, the holotype (S. M. E 18684), Tyrrellfjellet.

Figures 13–15. *Cancrinella tenuissima* sp. nov., 13–14, respectively ventral and lateral views of pedicle valve, the holotype (S. M. E 18383), Brachiopod Chert, Komarovfjellet, Oslobreen, Ny Friesland; 15, holotype enlarged ×2 to show the form of the sculpture.

Figures 16–21. *Cancrinella crassa* sp. nov., Cyathophyllum Limestone, Komarovfjellet, Oslobreen, Ny Friesland. 16, ventral view of pedicle valve, paratype (S. M. E 18393); 17, the same enlarged ×2 to show the form of the sculpture; 18, lateral view of pedicle valve, paratype (S. M. E 18395); 19, natural external mould of brachial valve, paratype (S. M. E 18394); 20–21, respectively ventral and dorsal views of the holotype (S. M. E 18389).

Figures 22–26. *Anidanthus aagardi* (TOULA). 22, ventral view of pedicle valve (S. M. E 18801), Middle Brachiopod Chert, Gipshuken, Bünsow Land; 23–25, respectively ventral view, natural external mould of brachial valve, and dorsal view of P. M. O. A 26215, Brachiopod Chert, Rejmyrefjellet; 26, figure 24 enlarged ×2.

Figures 27–29. *Megousia weyprechti* (TOULA), Brachiopod Chert. 27, dorsal view of exfoliated specimen (S. M. E 18088), Rundodden, Sassenfjorden; 28–29, respectively posterior and ventral views of pedicle valve (S. M. E 18031), Mertonberget, Chydeniusbreen, Ny Friesland.

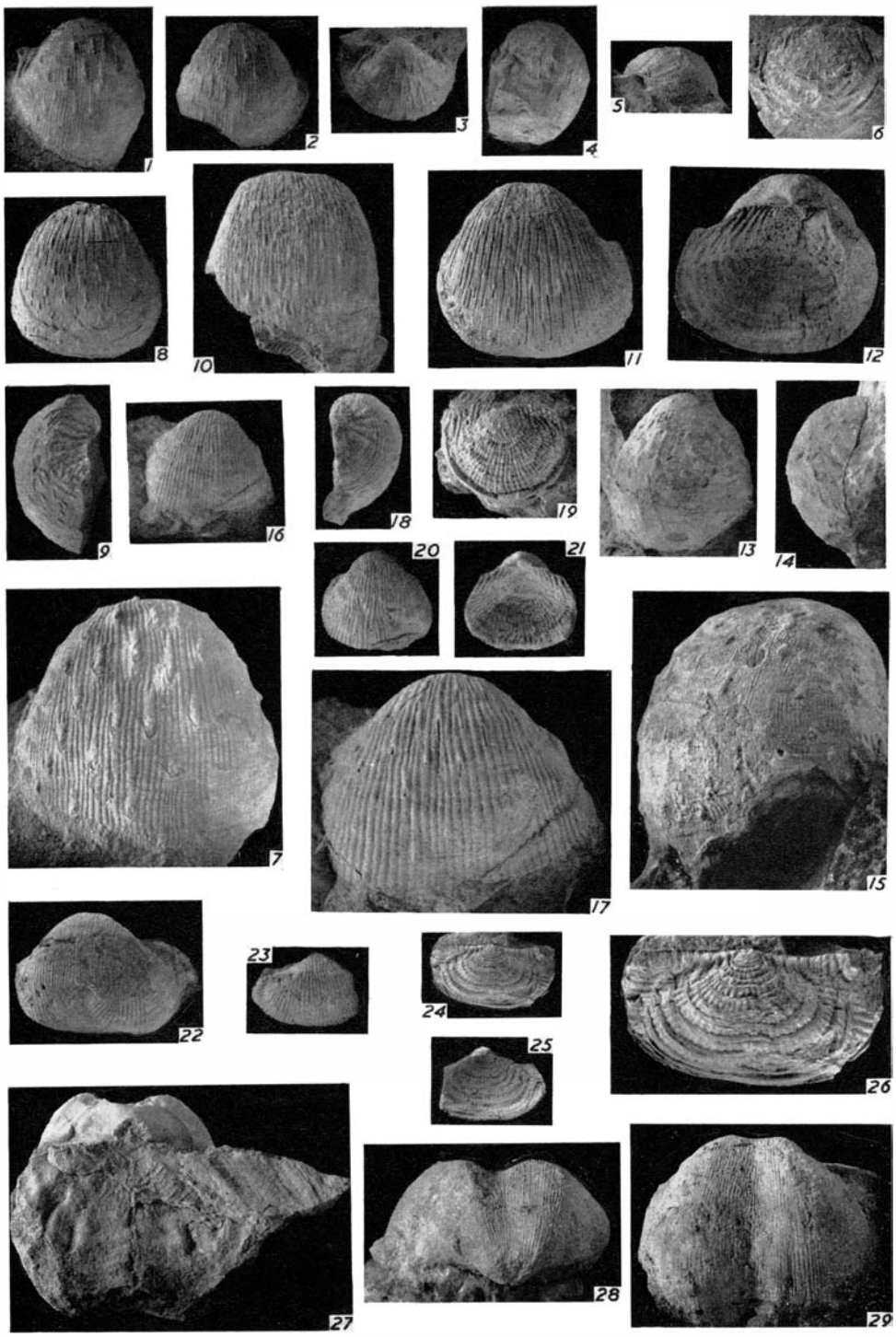
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PLATE 13

Figures 1–6. *Megousia weyprechti* (TOULA), Brachiopod Chert. 1, anterior view of pedicle valve (S. M. E 18067), Belvedere, Sassenfjorden; 2–3, respectively posterior and lateral views of the lectotype, internal mould of pedicle valve (Naturhistorisches Museum, Vienna, 1876/VII/10), figured by TOULA (1874, pl. 5, fig. 2 a, b), Sørkappøya; 4, exfoliated brachial valve interior with external mould of a complete ear (S. M. E 17993), Mertonberget, Chydeniusbreen, Ny Friesland; 5, natural external moulds of brachial valves (S. M. E 17992), Mertonberget; 6, silicified brachial valve interior (S. M. E 18415) station G 860, Oslobreen, Ny Friesland, uncoated with ammonium chloride.

Figures 7–15. *Megousia kulikii?* (FREDERICKS); 7–13, Spirifer Limestone, Bünsow Land. 7–9, respectively ventral view, lateral view, and interior of brachial valve of S. M. E 18621, Bjonahamna; 10, ventral view of pedicle valve (S. M. E 18224), Templet; 11–13, respectively posterior, ventral and interior views of silicified pedicle valve (S. M. E 17628), Tyrrellfjellet (fig. 13 uncoated with ammonium chloride); 14–15, respectively interior and exterior views of silicified brachial valve, (X 679), Brachiopod Limestone, Heimberget, Oscar II Land, uncoated with ammonium chloride.

Figures 16–22. *Megousia harlandi* sp. nov., Spirifer Limestone, Bjonahamna, Tempelfjorden; 17, 18, 20 uncoated with ammonium chloride. 16–18, respectively lateral view, dorsal view, and exfoliated brachial valve interior of the holotype (S. M. E 18555); 19, interior of silicified pedicle valve (S. M. E 18554); 20, dorsal view of paratype (S. M. E 18544); 21–22, respectively lateral and ventral views of pedicle valve, paratype (S. M. E 18545).

Figures 23–26. *Muirwoodia mammata* (KEYSERLING), Brachiopod Limestone, Skivefjellet, Oscar II Land. 23, ventral view of pedicle valve (X 624.1); 24–26, respectively postero-ventral, lateral and anterior views of pedicle valve (X 624.2).

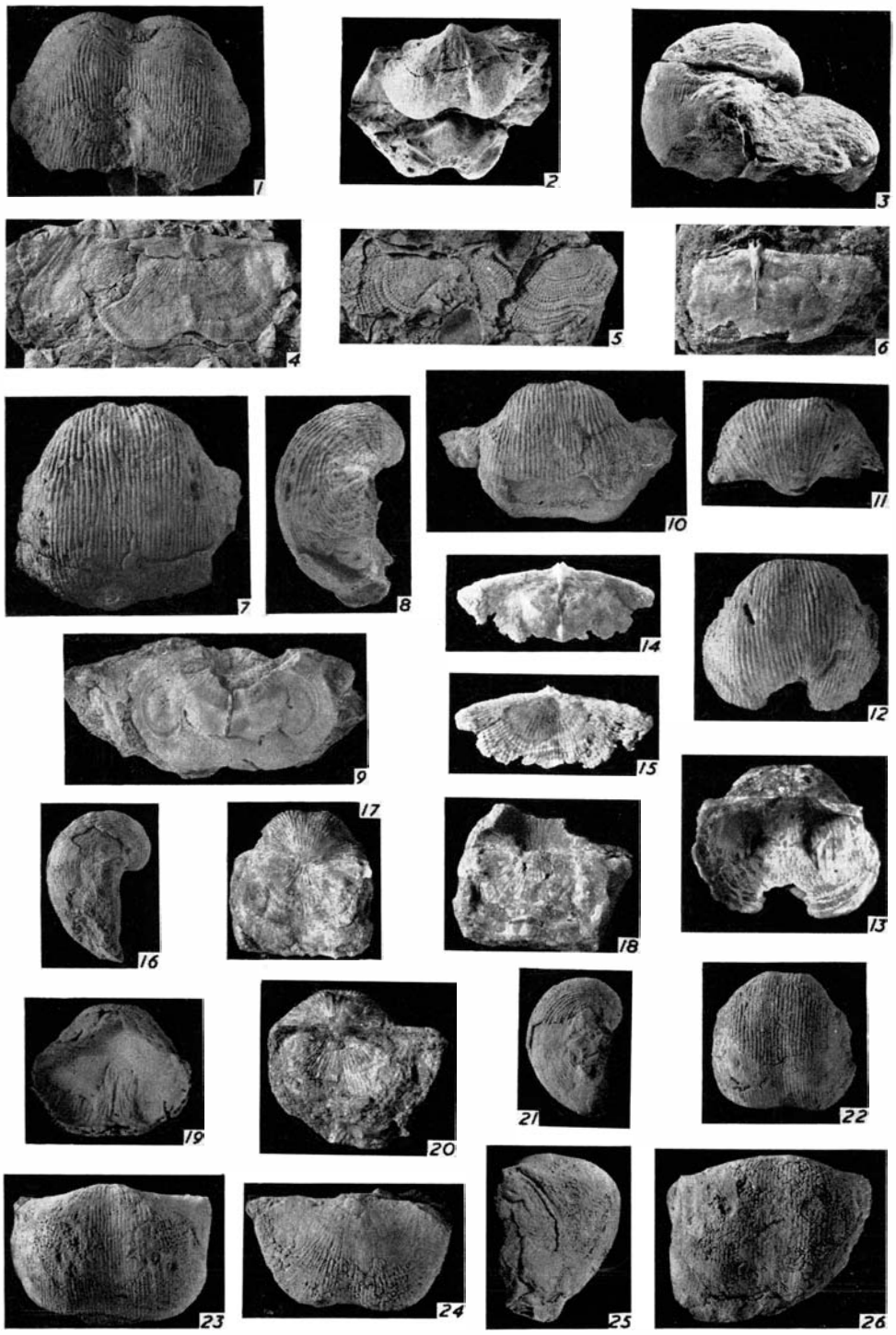
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PLATE 14

Figures 1–4. *Yakovlevia impressa* (TOULA), Spirifer Limestone, Bünsow Land; uncoated with ammonium chloride. 1–3, respectively ventral, lateral, and dorsal views of S. M. E 18656, Bjonahamna; 4, interior of silicified pedicle valve (S. M. E 18682), Tyrrellfjellet.

Figures 5–6. *Muirwoodia duplex* (WIMAN), respectively lateral and ventral views of pedicle valve (S. M. E 18808), Middle Brachiopod Chert, Gipshuken, Bünsow Land. Uncoated with ammonium chloride.

Figures 7–9. *Monticulifera? lovéni* (WIMAN), Brachiopod Chert, Mertonberget, Chydeniusbreen, Ny Friesland. 7, natural external mould of brachial valve (S. M. E 18026); 8, ventral view of pedicle valve (S. M. E 18036); 9, part of S. M. E 18036, enlarged $\times 2$ to show the form of the sculpture.


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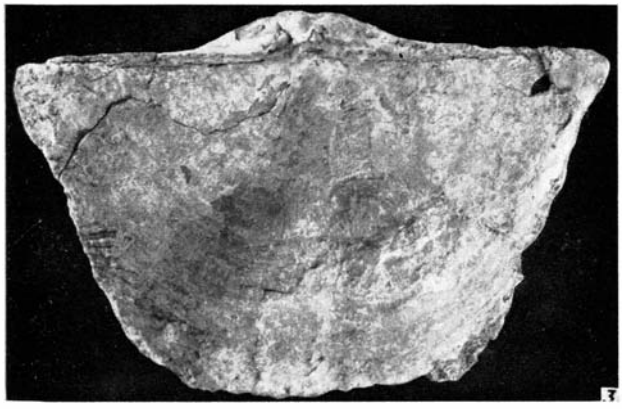
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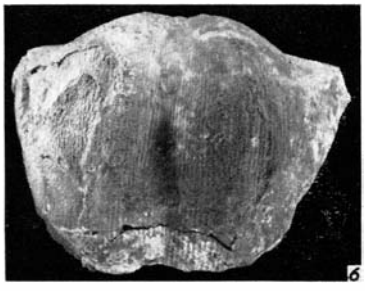
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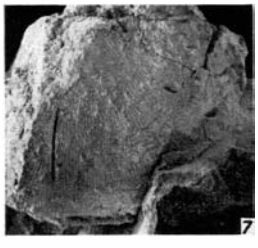
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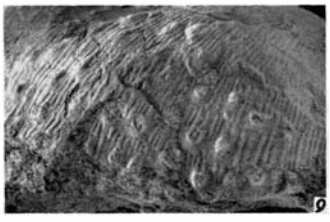
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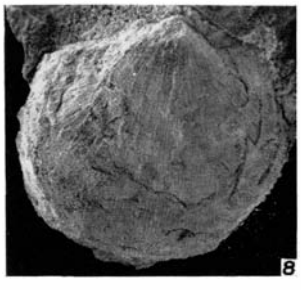
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PLATE 15

Figure 1. *Chonetes* sp., ventral view of pedicle valve (S. M. E 17963); Cora Limestone, Ymerdalen, Bjørnøya.

Figures 2–6. *Chonetina superba* sp. nov., Middle Brachiopod Chert, Gipshuken, Bünsow Land. 2–3, respectively ventral and dorsal views of the holotype (S. M. E 17721); 4, ventral view of paratype (S. M. E 17722); 5, dorsal view of paratype (S. M. E 17714); 6, ventral view of paratype (S. M. E 17724).

Figures 7–9. *Paeckelmannia forbesi* sp. nov., Upper Wordiekammen Limestone, Gipsvika, Bünsow Land. 7, ventral view of pedicle valve, the holotype (S. M. E 18262), ×2; 8, ventral view of pedicle valve (S. M. E 18261), ×2; 9, block crowded with mainly exfoliated valves, paratypes (S. M. E 18251–60).

Figure 10. *Mesolobus?* sp., ventral view of S. M. E 18186, ×2; Lower Wordiekammen Limestone, Teltfjellet, Bünsow Land.

Figures 11–13. *Paeckelmannia capitolina* (TOULA), Brachiopod Chert. 11, block with two exfoliated pedicle valves (S. M. E 18163–4), station G 859, Oslobreen, Ny Friesland; 12, plaster replica of pedicle valve (Naturhistorisches Museum, Vienna, 1875/XLI/?), figured by TOULA (1875 c, pl. 8, fig. 9 a); 13, block with exfoliated pedicle and brachial valve interiors (S. M. E 18173–4), station G 860, Oslobreen.

Figures 14–18. *Paeckelmannia* cf. *permiana* (SCHUMARD), Brachiopod Chert. Uncoated with ammonium chloride. 14–17, ventral and dorsal views of two specimens (R. M. S. Br. 939), ×2, Angelinberget, Nordaustlandet, determined by TSCHERNYSCHEW as *Chonetes* sp. cf. *geinitzi* WAAGEN; 18, block with brachial and pedicle valves (S. M. E 18309–13), shore south of Kapp Wijk.

Figures 19–21. *Lissochonetes spitzbergensis* (TOULA). Brachiopod Chert. 19, plaster replica, ×2 of pedicle valve, lectotype (Naturhistorisches Museum, Vienna, 1875/XLI/9), figured by TOULA (1875 a, pl. 1, fig. 10); 20, ventral view of pedicle valve (P. M. O. A 28332), ×2, Reinodden, Bellsund; 21, ventral view of pedicle valve (S. M. E 18054), ×2, Cepheusfjellet, Polarisbreen, Ny Friesland.

Figures 22–24. *Wellerella?* sp., respectively dorsal, anterior, and lateral views of R. M. S. Br. 998, × 2, Cora Limestone, Ymerdalen, Bjørnøya.

Figure 25. *Camerotoechia?* cf. *krotovi* (TSCHERNYSCHEW), ventral view of pedicle valve (S. M. E 18448), Cyathophyllum Limestone, Cepheusfjellet, Polarisbreen, Ny Friesland.

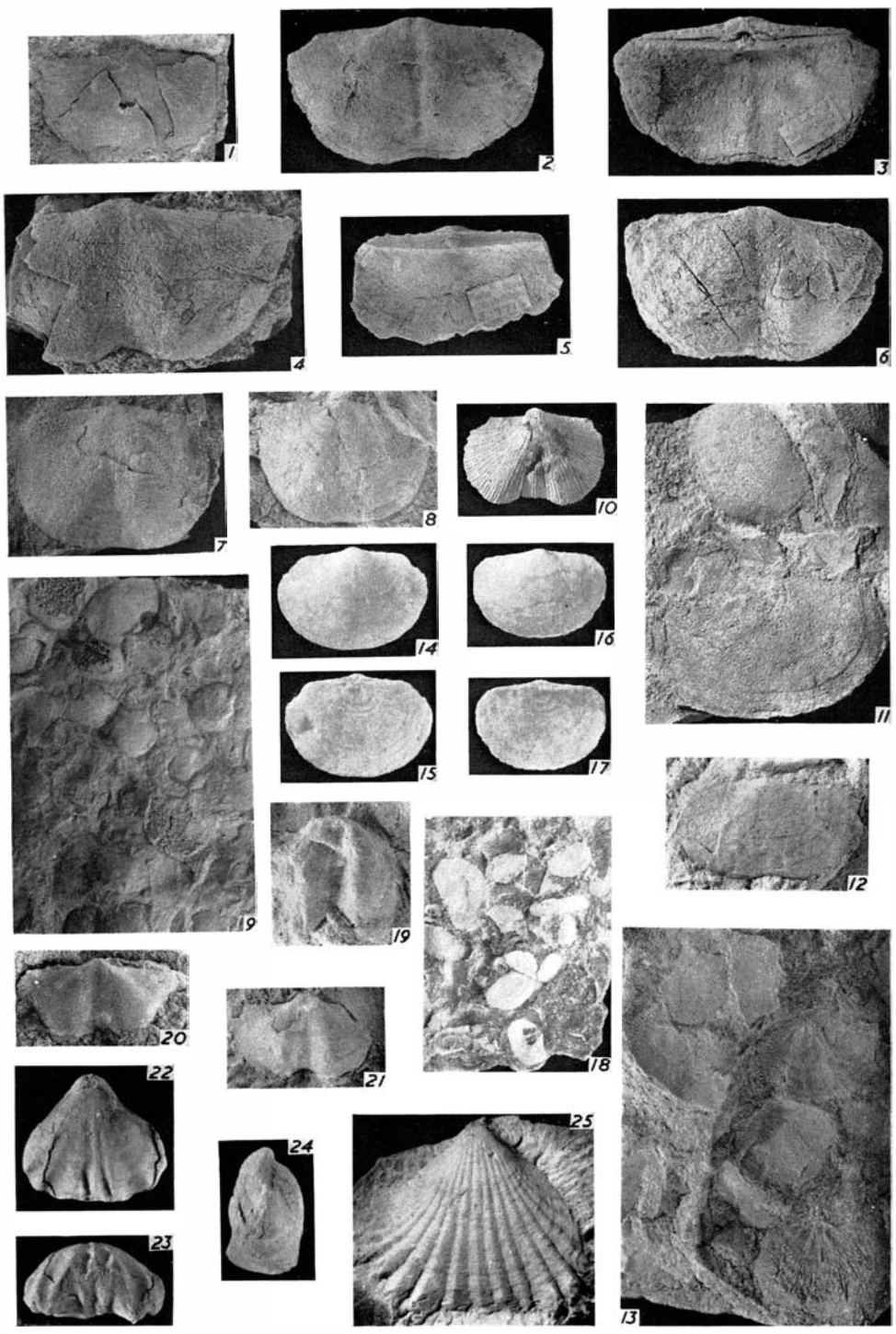
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PLATE 16

Figures 1–3. *Camerotoechia* sp., respectively ventral, anterior and lateral views of S. M. E 18698, scree *ex* Upper Wordiekammen Limestone, Tyrrellfjellet, Bünsow Land.

Figures 4–9. *Camerophoria spitzbergiana* STEPANOV, Spirifer Limestone, Bjonahamna, Tempelfjorden. 4–6, respectively dorsal, ventral, and anterior views of S. M. E 18490; 7–9, respectively dorsal, lateral, and ventral views of S. M. E 18491.

Figures 10–11. *Camerophoria* sp. aff. *spitzbergiana* STEPANOV, Middle Brachiopod Chert, Gipshuken, Bünsow Land. 10, ventral view of S. M. E 17682; 11, ventral view of S. M. E 18267.

Figure 12. *Camerophoria* cf. *mutabilis* TSCHERNYSCHEW, dorsal view of R. M. S. Br. 66 c, Brachiopod Chert, Bellsund.

Figures 13–16. *Laevicamera* cf. *arctica* (HOLTEDAHL), Cyathophyllum Limestone. 13, posterior view of S. M. E 17284 and E 17287 (counterparts), Führmeisterdalen, Tempelfjorden; 14, posterior view of S. M. E 18857, Pachtusovfjellet, Ny Friesland; 15–16, respectively dorsal and lateral views of S. M. E 17285, Führmeisterdalen.

Figure 17. *Laevicamera* sp., lateral view of S. M. E 17971, Cora Limestone, Ymerdalen, Bjørnøya.

Figures 18–21. *Rhynchopora nikitini* TSCHERNYSCHEW, respectively anterior, dorsal, lateral and ventral views of S. M. E 18274, ×2, Spirifer Limestone, Wardropfjellet, Bünsow Land.

Figures 22–25. *Rhynchopora* sp., respectively anterior, dorsal, lateral, and ventral views of S. M. E 18202, ×2, Upper Gypsiferous Series, Burn Murdochbreen, Bünsow Land.

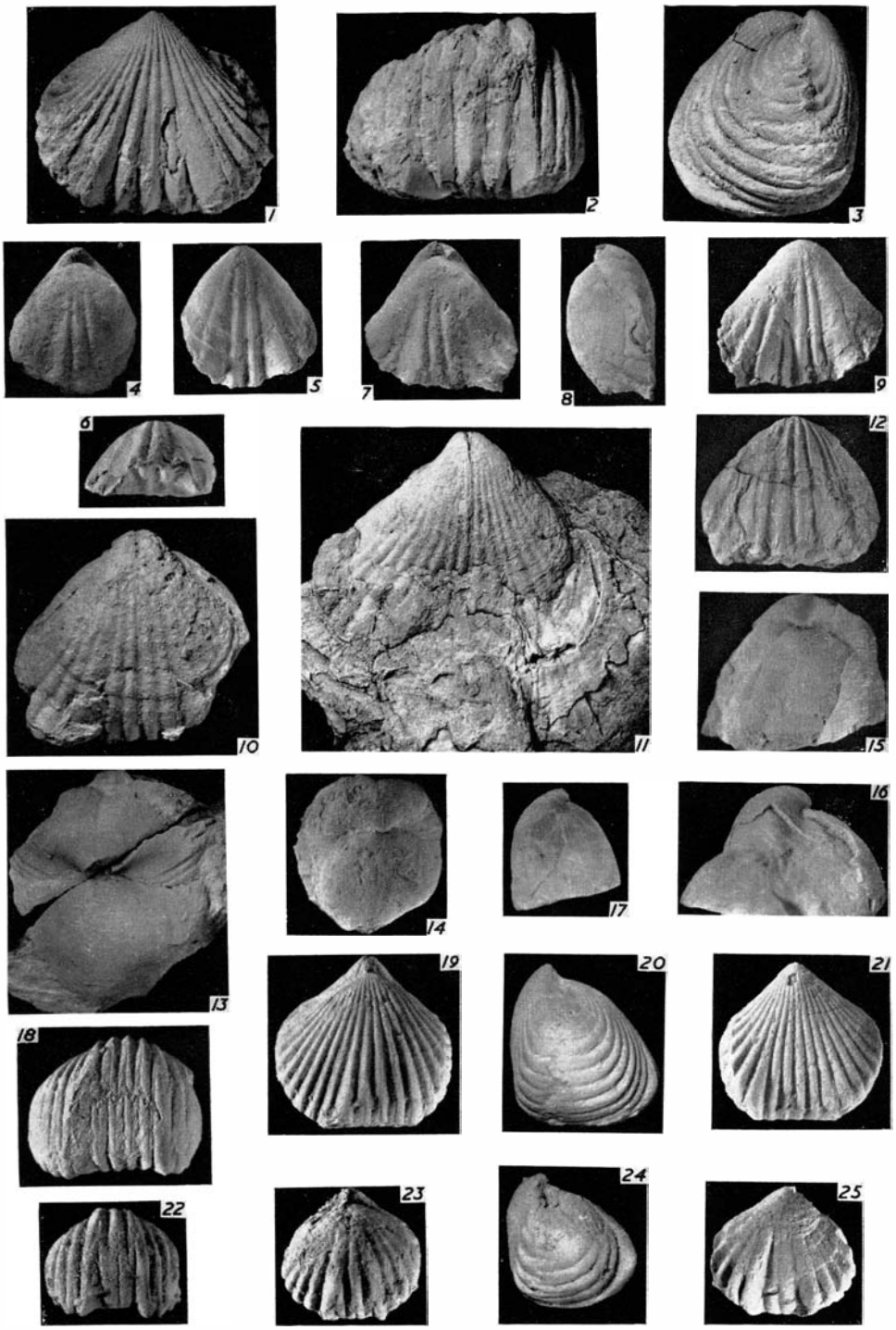
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PLATE 17

Figures 1–3. *Neophridacothyris asiatica* (CHAO), Cora Limestone, Ymerdalen, Bjørnøya. 1–2, respectively dorsal and anterior views of R. M. S. Br. 1121 l; 3, lateral view of R. M. S. Br. 1121 m.

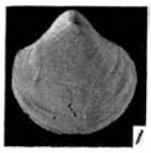
Figures 4–5. *Neophridacothyris* sp. A, respectively dorsal and lateral views of P. M. O. A 26414, Brachiopod Chert, Sveltihel, Sassenfjorden.

Figure 6. *Neophridacothyris* sp. B, exterior of damaged valve (S. M. E 18563), Spirifer Limestone, Bjonahamna, Tempelfjorden.

Figures 7–9. *Spirifer striato-plicatus* sp. nov., Spirifer Limestone, Bjonahamna, Tempelfjorden. 7, exterior of pedicle valve, paratype (S. M. E 18583); 8–9, respectively exterior and interior of pedicle valve, the holotype, (S. M. E 18588).

Figures 10–11. *Neospirifer sub-fasciger?* LICHAREW. 10, natural internal mould of brachial valve (S. M. E 18271), scree *ex* Upper Wordiekammen Limestone, Tyrellfjellet, Bünsow Land; 12, natural internal mould of pedicle valve (S. M. E 18772), Upper Wordiekammen Limestone, Gipsvika, Bünsow Land.

Figures 12–16. *Brachythyrina arctica* sp. nov., Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land. 12–13, respectively ventral and dorsal views of the holotype (X 632.1); 14–16, respectively ventral, lateral and dorsal views of paratype (X 632.12).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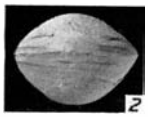
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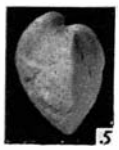
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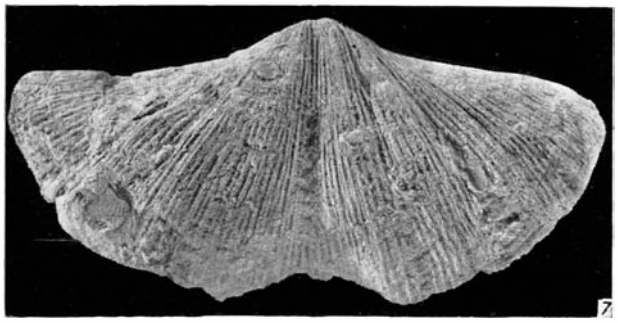
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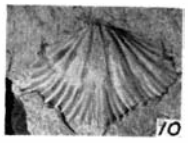
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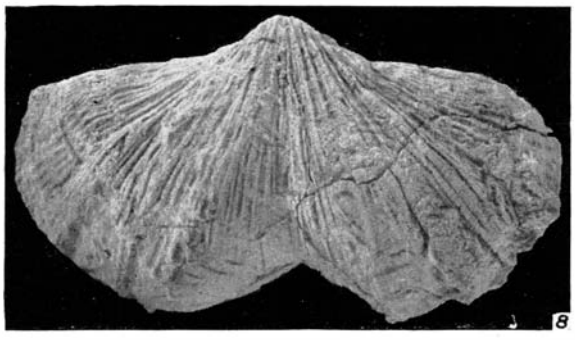
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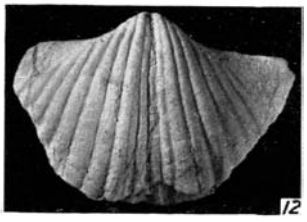
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PLATE 18

Figure 1. *Spirifer striato-plicatus* sp. nov., exterior of brachial valve, paratype (S. M. E 18593), Spirifer Limestone, Bjonahamna, Tempelfjorden.

Figure 2. *Spirifer striato-paradoxus* TOULA, exterior of brachial valve, (S. M. E 18599), Spirifer Limestone, Bjonahamna, Tempelfjorden.

Figures 3–5. *Spirifer* cf. *poststriatus* NIKITIN, Brachiopod Chert, Mertonberget, Chydeniusbreen, Ny Friesland. 3, ventral view of S. M. E 18013; 4–5, respectively dorsal and lateral views of S. M. E 17991.

Figure 6. *Spirifer?* cf. *osborni* HARKER, ventral view of pedicle valve (R. M. S. Br. 878), Bellsund.

Figures 7–8. *Neospirifer* cf. *fasciger* (KEYSERLING), respectively anterior and ventral views of natural internal mould, (S. M. E 17919), Spirifer Limestone, Lundenæringane, Bjørnøya.

Figure 9. *Neospirifer* cf. *tegulatus* (TRAUTSCHOLD), ventral view of P. M. O. A 26292, upper part of Cyathophyllum Limestone, Skedvifjella, Von Postbreen.

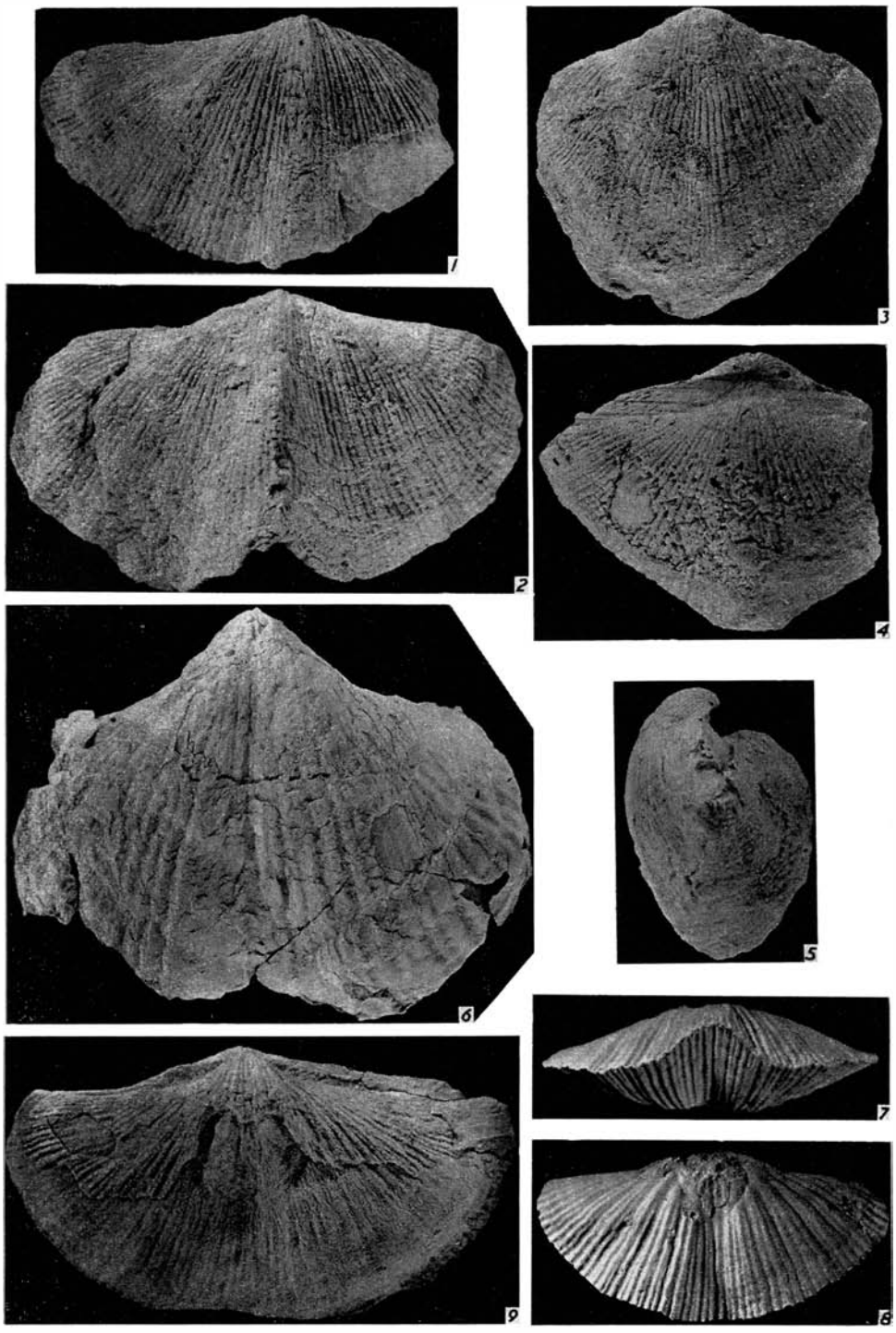
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PLATE 19

Figure 1. *Neospirifer* cf. *tegulatus* (TRAUTSCHOLD), dorsal view of P. M. O. A 26293, upper part of Cyathophyllum Limestone, Skedvifjella, Von Postbreen.

Figures 2–6. *Licharewia spitsbergiana* sp. nov., Brachiopod Chert Mertonberget, Chydeniusbreen, Ny Friesland. 2–4, respectively dorsal, ventral and lateral views of the holotype (S. M. E 18004); 5–6, respectively ventral and lateral views of paratype (S. M. E 18003).

Figures 7–9. *Licharewia* cf. *grewingki* (NETSCHAJEW). 7–8, respectively ventral view and interarea of pedicle valve (S. M. E 18061), Brachiopod Chert, Cepheusfjellet, Polarisbreen, Ny Friesland; 9, ventral view of pedicle valve, (S. M. E 18266), Middle Brachiopod Chert, Gipshuken, Bünsow Land.

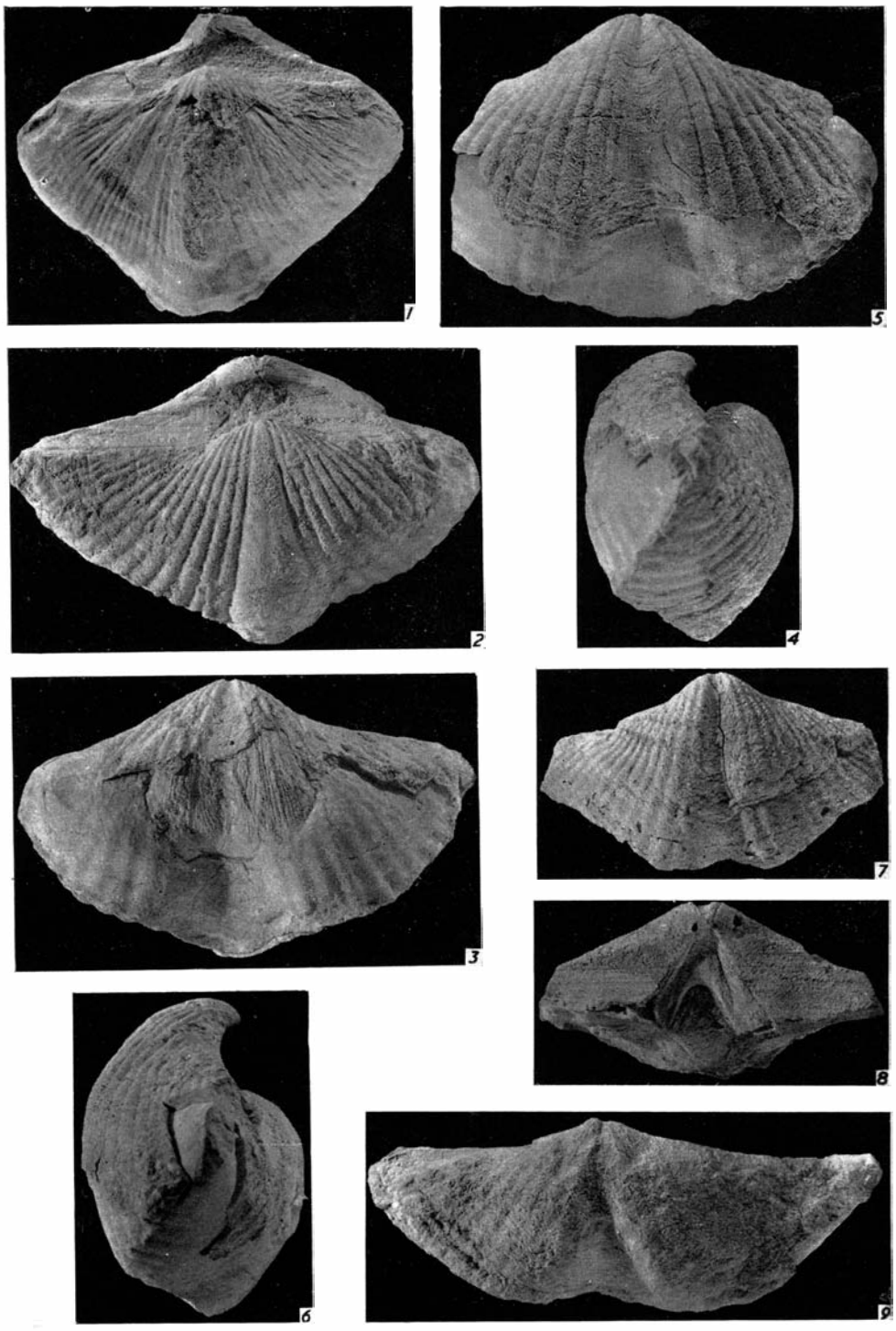
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PLATE 20

Figures 1–3. *Choristites aliforme* sp. nov. 1, ventral view of pedicle valve, the holotype (S. M. E 18108), Passage Beds, north-east shore of Adolfbukta, Billefjorden; 2, postero-ventral view of pedicle valve, paratype (S. M. E 18109), Passage Beds, north-east shore of Adolfbukta; 3, dorsal view of S. M. E 17984, Ambigua Limestone, north of Kapp Kåre, Bjørnøya.

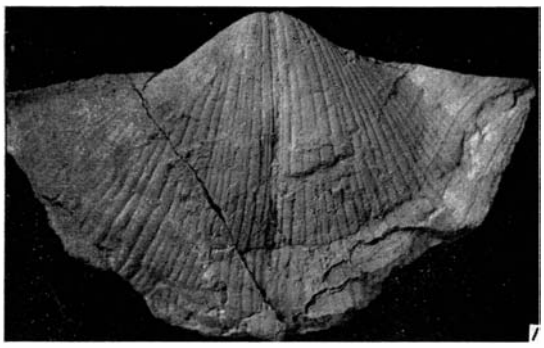
Figures 4–6. *Spiriferella* aff. *interplicata* (ROTHPLETZ), respectively ventral, lateral, and dorsal views of S. M. E 17737, Middle Brachiopod Chert, Gipshuken, Bünsow Land.

Figure 7. *Spiriferella draschei* (TOULA), anterior view of exfoliated specimen (S. M. E 17596), Spirifer Limestone, Gipshuken, Bünsow Land.

Figures 8–10. *Spiriferella keilhavii* (VON BUCH), Spirifer Limestone. 8, ventral view of S. M. E 18341, Miseryfjellet, Bjørnøya; 9, ventral view of S. M. E 18602, Bjonahamna, Tempelfjorden; 10, ventral view of S. M. E 18613, Bjonahamna.

Figures 11–12. *Spiriferella* cf. *saranae* (VERNEUIL), respectively ventral and lateral views of pedicle valve (S. M. E 17977), Cora Limestone, Ymerdalen, Bjørnøya.

Figure 13. *Pterospirifer cordieri* (ROBERT), interior of worn, silicified pedicle valve (S. M. E 18343), Spirifer Limestone, Miseryfjellet, Bjørnøya.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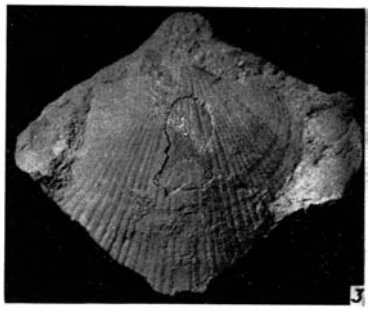
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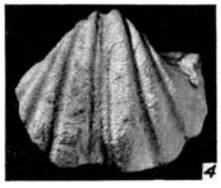
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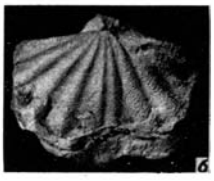
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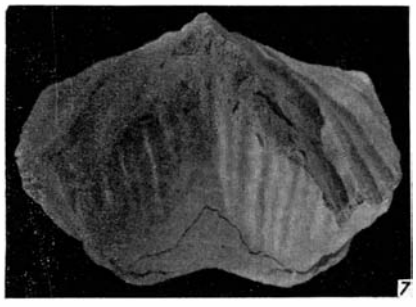
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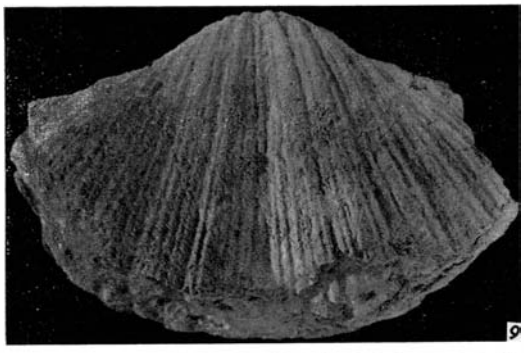
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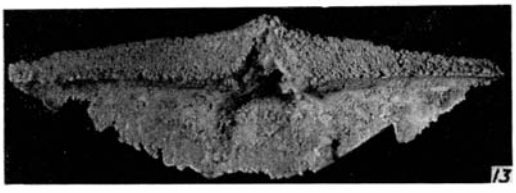
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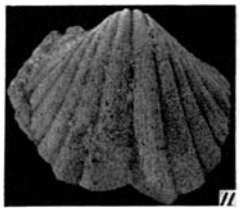
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PLATE 21

Figures 1–3. *Paeckelmannella* aff. *expansa* (TSCHERNYSCHEW). 1, ventral view of pedicle valve (S. M. E 18082), Brachiopod Chert, Thiisbukta, Kongsfjorden; 2, dorsal view of crushed, silicified specimen (D. 09 B 8/09 B 12), Spirifer Limestone, Garwoodtoppen, Kongsfjorden; 3, brachial valve interior (S. M. E 18789), Middle Brachiopod Chert, Gipshuken, Bünsow Land.

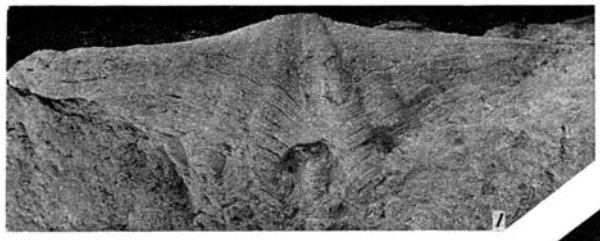
Figures 4–5. *Pterospirifer cordieri* (ROBERT), respectively ventral and dorsal views of R. M. S. Br. 394, Brachiopod Chert, Akseløya, Bellsund.

Figures 6–8. *Spiriferinae* gen. and sp. nov., respectively dorsal, ventral, and lateral views of S. M. E 17979, Cora Limestone, Ymerdalen, Bjørnøya.

Figures 9–10. *Martinia* sp. A., respectively dorsal and lateral views of S. M. E 17913, Lower Gypsiferous Series, Ebbadalen, Billefjorden.

Figures 11–12. *Martinia?* sp. B., respectively dorsal and lateral views of P. M. O. H 4968, Spirifer Limestone, Trygghamna, Isfjorden.

Figures 13–16. *Cleiothyridina royssiana* (KEYSERLING), Spirifer Limestone. 13, ventral view of S. M. E 18218, west of Kapp Schoultz, Tempelfjorden; 14, ventral view of S. M. E 18482, Bjonahamna, Tempelfjorden; 15, interior of pedicle valve (S. M. E 18162), station G 859, Oslobreen, Ny Friesland; 16, antero-ventral view of damaged specimen showing spiral brachidium (S. M. E 18483), Bjonahamna, uncoated with ammonium chloride.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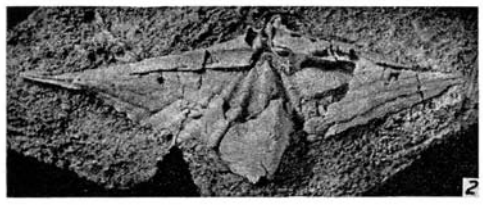
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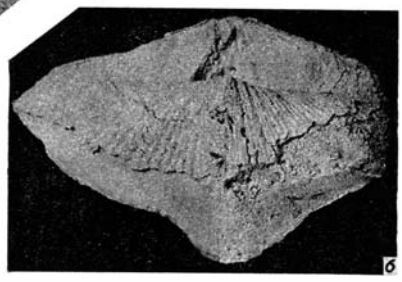
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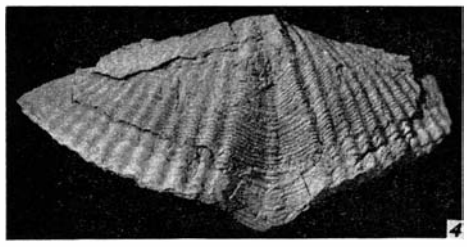
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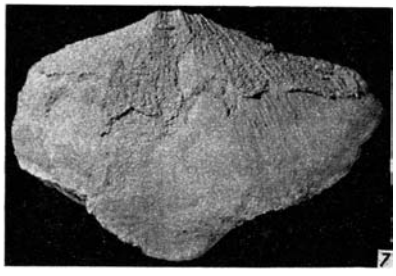
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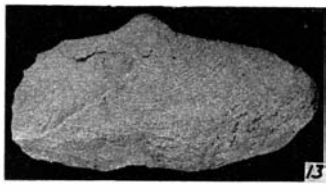
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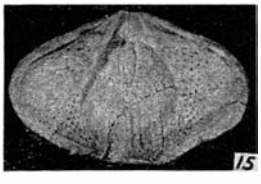
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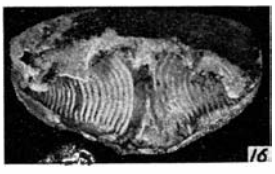
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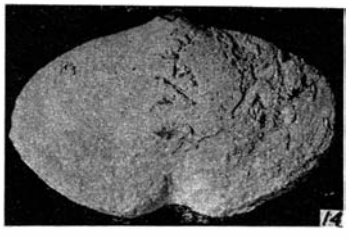
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PLATE 22

Figures 1–2. *Cleiothyridina royssiana* (KEYSERLING) young, silicified specimens, Spirifer Limestone, Bjonahamna, Tempelfjorden. Uncoated with ammonium chloride. 1, brachial valve interior of S. M. E 18462, × 2; 2, dorsal view of S. M. E 18461, × 2.

Figures 3–4. *Cleiothyridina kotlukovi* STEPANOV, Brachiopod Chert. 3, dorsal view of S. M. E 18062, Mertonberget, Chydeniusbreen, Ny Friesland; 4, ventral view of natural internal mould (X 669), Heimberget, Oscar II Land.

Figures 5–7. *Cleiothyridina* cf. *stuckenbergi* (NETSCHAJEW), Brachiopod Chert, Ahlstrandodden, Bellsund. 5, dorsal view of P. M. O. A 28316; 6–7, respectively lateral and dorsal views of P. M. O. A 28313.

Figures 8–10. *Cleiothyridina* cf. *sibirica* EINOR, upper part of Cyathophyllum Limestone, Kapp Schoultz, Tempelfjorden. 8–9, respectively dorsal and ventral views of P. M. O. A 26346; 10, anterior view of P. M. O. A 26342.

Figures 11–13. *Cleiothyridina* aff. *maynci* DUNBAR, respectively dorsal, ventral and interior views of S. M. E 17324, Upper Wordiekammen Limestone, Brisingefjellet, Bünsow Land.

Figures 14–17. *Composita ambigua* (J. SOWERBY), Tårnkanten Sandstone, Robertsonfjellet, Oscar II Land. 14–15, respectively dorsal and ventral views of X 635.1; 16–17, respectively dorsal and ventral views of natural internal mould (X 635.2).

Figures 18–20. *Composita* sp. A., respectively dorsal, ventral and anterior views of R. M. S. Br. 102177, locality unknown.

Figures 21–24. *Composita* sp. B., upper part of Cyathophyllum Limestone, Mertonberget, Chydeniusbreen, Ny Friesland. 21, dorsal view of exfoliated specimen (S. M. E 17998); 22–24, respectively ventral, lateral, and anterior views of exfoliated specimen (S. M. E 17995).

Figure 25. *Hustedia* sp. A., ventral view of complete specimen, (P. M. O. A 26331), ×2, Cyathophyllum Limestone, Högbomfjellet, Bünsow Land.

Figure 26. *Hustedia?* sp. B., ventral view of pedicle valve (S. M. E 18116), ×2, Passage Beds, Sfinksen, Billefjorden.

Figure 27. *Eumetria* aff. *serpentina* (DE KONINCK), dorsal view of natural internal mould (R. M. S. Br. 174 g), ×2, Ambigua Limestone, Oswaldfjellet, Bjørnøya.

Figure 28. *Pseudosyringothyris borealis* sp. nov., posterior view of plaster replica of the holotype (S. M. E 18575), Spirifer Limestone, Bjonahamna, Tempelfjorden. Uncoated with ammonium chloride.

Figure 29. *Spiriferina* sp. A., interior of brachial valve (S. M. E 18120), ×2, Passage Beds, Sfinksen, Billefjorden.

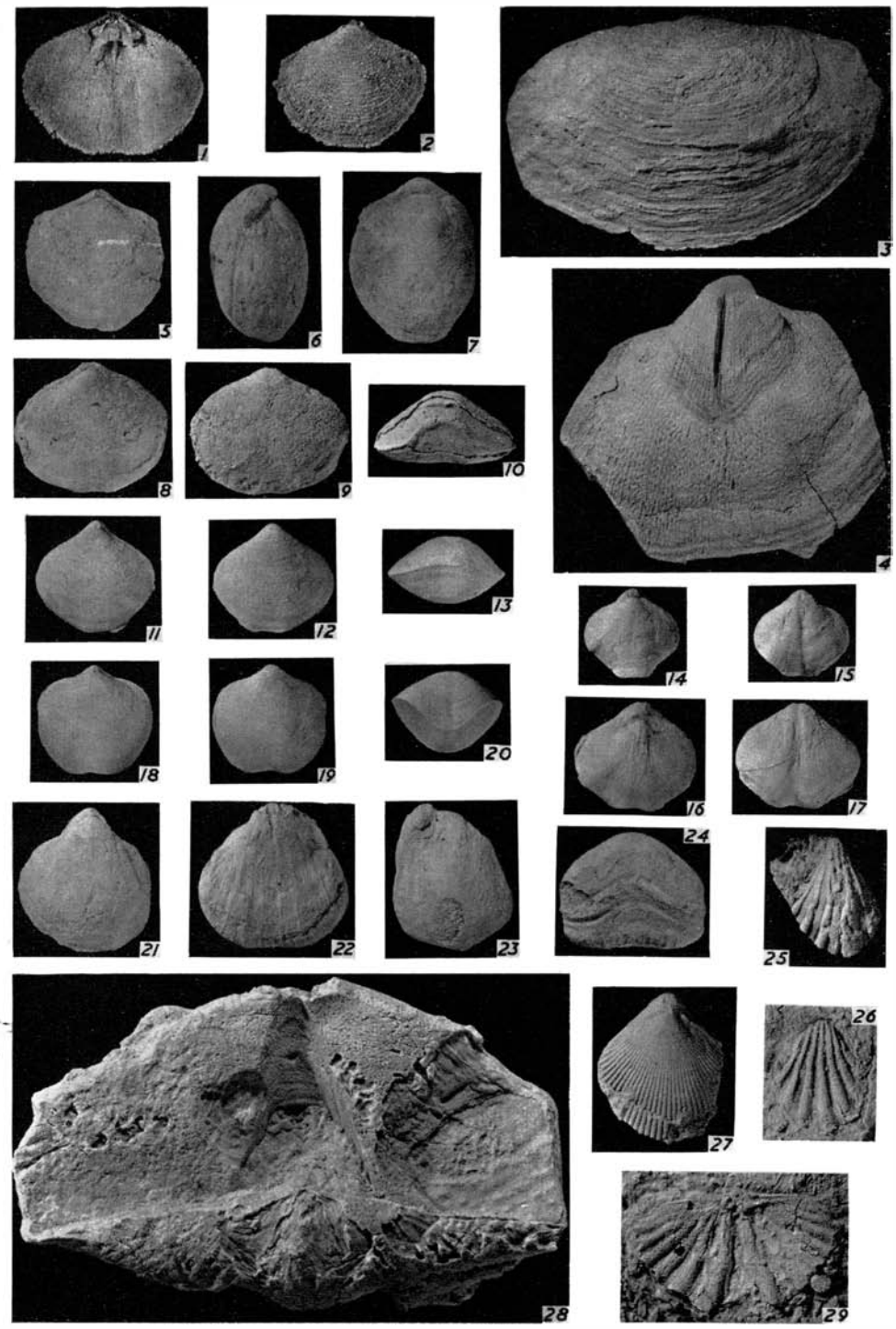
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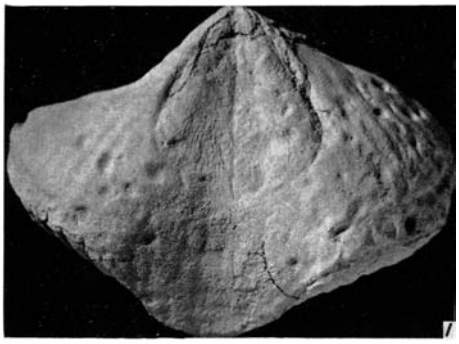
PLATE 23

Figures 1–3. *Pseudosyrinx wimani* sp. nov., respectively ventral, posterior and dorsal views of natural internal mould, the holotype, (S. M. E 17500), Spirifer Limestone, Usherfjellet, Bünsow Land.

Figures 4–5. *Pseudosyrinx arcticus?* (WHITFIELD), respectively posterior and lateral views of S. M. E 17112, Spirifer Limestone, Tyrellfjellet, Bünsow Land.

Figures 6–9. *Pseudosyrinx* sp., Spirifer Limestone. 6, interior of silicified pedicle valve (S. M. E 18580), Bjonahamna, Tempelfjorden; 7, exterior of brachial valve (P. M. O. A 26247), Rejmyrefjellet, Tempelfjorden; 8–9, respectively exterior and interior of silicified brachial valve (S. M. E 18581), Bjonahamna.

Figure 10. *Pseudosyringothyris* sp., plaster replica of fragmentary pedicle valve (S. M. E 18576), Spirifer Limestone, Bjonahamna, Tempelfjorden.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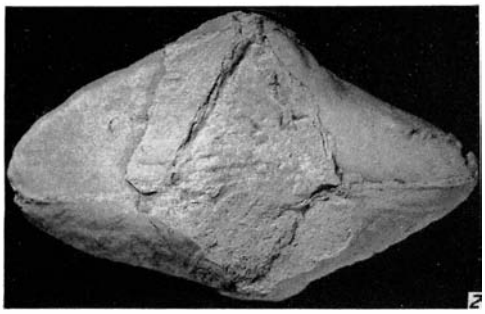
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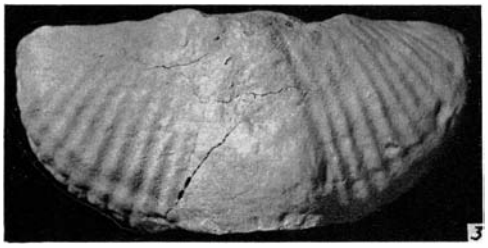
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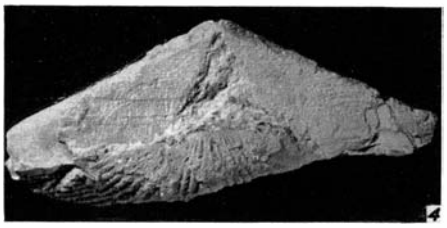
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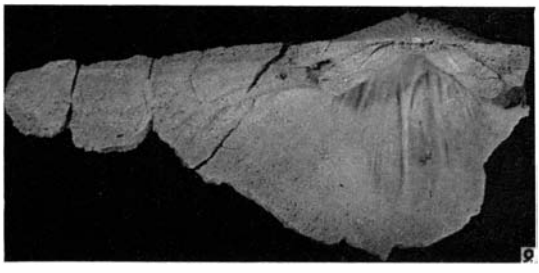
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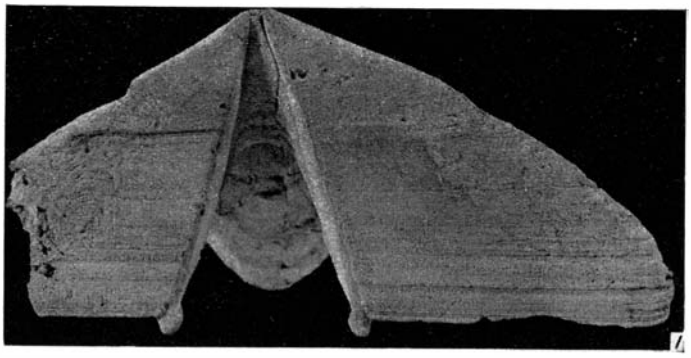
PLATE 24

Figures 1–4. *Pseudosyringothyris borealis* sp. nov. 1–3, respectively interarea, ventral view, and interior of pedicle valve; paratype (R. M. S. Br. 101926), Spirifer Limestone, Tempelfjorden. 4, ventral view of pedicle valve (R. M. S. Br. 834), labelled *Spirifer lovéni* by WIMAN, ?Brachiopod Chert, Lovénberget, Ny Friesland.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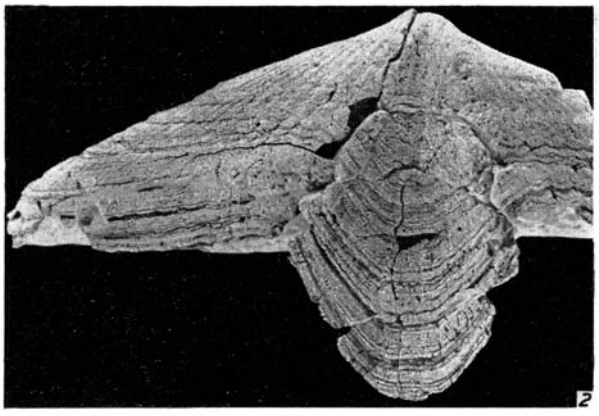
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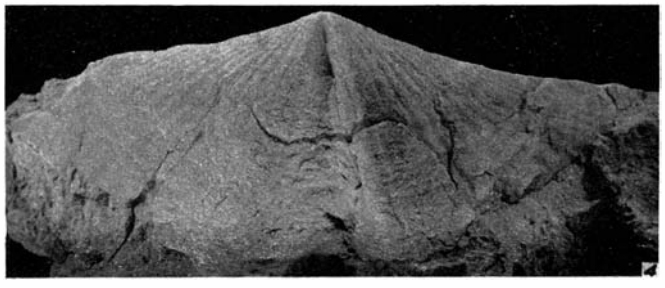
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PLATE 25

Figures 1–4. *Dielasma giganteum* TSCHERNYSCHEW, natural internal moulds, Upper Cyathophyllum Limestone, Skedvifjella, Von Postbreen. 1–3, respectively dorsal, ventral and lateral views of P. M. O. A 26290; 4, dorsal view of P. M. O. A 26294.

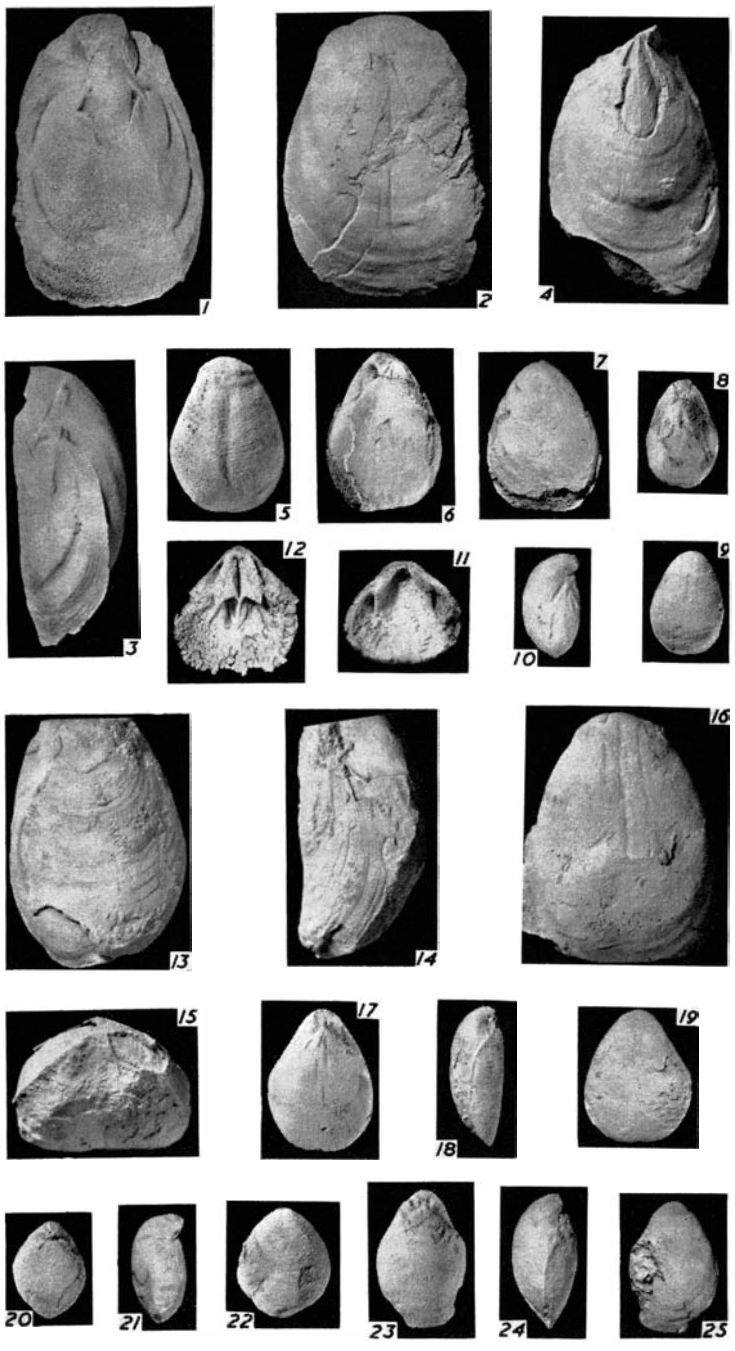
Figures 5–12. *Dielasma plica* (KUTORGA). 5, ventral view of natural internal mould (S. M. E 17415), Spirifer Limestone, Templet, Bünsow Land; 6–7, respectively dorsal and ventral views of R. M. S. Br. 102283, Cora Limestone, Ymerdalen, Bjørnøya; 8–10, respectively dorsal, ventral, and lateral views of natural internal mould (P. M. O. A 9771), Brachiopod Chert, Sørkappøya; 11–12, respectively interiors of silicified pedicle and brachial valves (S. M. E 18421–2), ×2, Spirifer Limestone, Skansbukta, Billefjorden.

Figures 13–16. *Dielasma* aff. *truncatum* WAAGEN, Spirifer Limestone, Bünsow Land. 13–15, respectively dorsal, lateral, and anterior views of S. M. E 18699, Tyrrellfjellet; 16, ventral view of natural internal mould (S. M. E 18539), Bjonahamna.

Figures 17–19. *Dielasma?* aff. *itaitubense* (DERBY), respectively dorsal, lateral, and ventral views of exfoliated specimen (S. M. E 17973), Cora Limestone, Ymerdalen, Bjørnøya.

Figures 20–22. *Dielasma tschernyscheffi* (GRABAU), Brachiopod Chert, Angelinberget, Nordaustlandet. 20, dorsal view of R. M. S. Br. 13 a. 1; 21–22, respectively lateral and ventral views of R. M. S. Br. 13 a. 2.

Figures 23–25. *Dielasma?* sp., respectively dorsal, lateral, and ventral views of R. M. S. Br. 102373, Ambigua Limestone, Oswaldfjellet, Bjørnøya.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